Coastal Protection and Restoration Authority of Louisiana

State of Louisiana

Office of Coastal Protection and Restoration

2010 Operations, Maintenance, and Monitoring Report

for

Hopedale Hydrologic Restoration (PO-24)

State Project Number PO-24

Priority Project List 8

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St. Bernard Parish

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I. Introduction

The 3,805 acre Hopedale Hydrologic Restoration Project (PO-24) is located southeast of Yscloskey, Louisiana, and is bordered by LA Hwy 46 on the west, the Mississippi River Gulf Outlet (MRGO) spoil deposition area to the north, and Louisiana Highway 624 and Bayou La Loutre to the south and east (Figure 1). The project area was formed as part of the St. Bernard Delta Lobe which took place approximately 3,000 years ago when the Mississippi River flowed through what is now Bayou La Loutre, laying the foundation for present day St. Bernard Parish. In 1958, construction began on a shipping channel that would cut through the relic delta and Bayou La Loutre. The channel, the Mississippi River Gulf Outlet (MRGO), was completed in 1968. As part of the construction of the MRGO, a spoil containment dike was constructed to allow placement of material from the MRGO dredging operation. The dike almost completely impounded the surrounding marsh with the exception of the Back Dike Borrow Canal which directly connected to Bayou La Loutre. A plug and water control structure was placed in the Back Dike Borrow Canal approximately 400 ft from its intersection with Bayou La Loutre. This structure consisted of three iron culverts with flap gates and provided drainage from the area while limiting tidal increases in minimal storm events. By the mid 1990's the original plug installed during the MRGO construction, prior to the PO-24 project initiation, had settled and the water control structure did not function as designed and was in need of repairs.

Wetlands in the PO-24 project area are classified as Mesohaline Wiregrass and have been adversely impacted by increases in flood durations due to the near complete impoundment caused by the construction of LA Hwy 624 and the MRGO. During construction of LA Hwy 624, four sets of non-gated culverts were installed under the highway. These culverts allowed tidal exchange between Bayou La Loutre and previously impounded wetlands north of the highway. The area is predominately brackish marsh (3,086 acres) and open water (719 acres) with a small amount of saline marsh, bottomland hardwoods and bottomland scrub/shrub within the MRGO spoil deposition area.

Figure 1. Hopedale Hydrologic Restoration (PO-24) project area map with project features.

In January 2004, construction began on the Hopedale water control structure at the junction of the Back Dike Borrow Canal and Bayou La Loutre. This involved removal of the 3 existing corrugated metal pipes and rock structure located within the Back Dike Borrow Canal and replacing it with a sheet pile/pipe pile gated structure, along with associated walkways and riprap protection. The site, which was completed in November 2004, also required construction of temporary closure dams for dewatering the existing canal.

The goals of the 3,805 acre Hopedale Hydrologic Restoration Project (PO-24) are to restore natural drainage patterns to sustain or enhance the deteriorating marsh and maintain or improve fisheries transport within the area.

The principle project features include:

- A sheet pile/pipe pile wall, which spans the channel and extends past both banks with an overall length of 137.9'. The top of cap plate elevation is set at +8.0' NAVD88.
- Three 82" Whipps diameter combination gates (flap/sluice gates) and two 24"x 84" Whipps fisheries access slots (fish gates) with the inverted elevation at –7.0' NAVD88
- A walkway with guardrails and warning signs on each side of the structure for operating the gates safely and for prohibiting unwanted access. The channel spans 115' from the canal banks and is covered with riprap (1' thick 10-lb. and 1.5' thick 55-lb.). The top of 55-lb. riprap along the canal bottom is set at elevation –8.0' NAVD88.

II. Maintenance Activity

a. Summary of Past Operation and Maintenance

In 2005 the Hopedale structure suffered some minor damage due to Hurricane Katrina. In 2007/2008 the repairs, at a cost of $64,900, were made as follows:

- Repaired and replaced all damaged fence panels.
- Replaced missing gate stem covers.
- Repaired damaged railing.
- Placed riprap into eroded areas.
- Replaced missing mechanical gate operator.
- Added support beam under walkway.

b. Inspection Purposes and Procedures

The purpose of the annual inspection of the Hopedale Hydrologic Restoration Project (PO-24) is to evaluate the constructed project features to identify any deficiencies and prepare a report detailing the condition of project features and recommended corrective actions needed. Should it be determined that corrective actions are needed, OCPR shall provide, in the report, a detailed cost estimate for engineering, design, supervision, inspection, and construction contingencies, and an assessment of the urgency of such repairs (O&M Plan April 21, 2005). The annual inspection report also contains a summary of maintenance projects and an estimated projected budget for the upcoming three (3) years for operation, maintenance and rehabilitation. The three (3) year projected operation and maintenance budget is shown in Appendix C. A summary of past operation and maintenance projects completed since completion of the project can be found in Section IIa.

An inspection of the Hopedale Hydrologic Restoration Project (PO-24) was held on April 30, 2010, by Barry Richard of OCPR. This inspection coincided with the closure of the structure which was prompted by the explosion of the Deepwater Horizon Oil Rig and subsequent oil spill. The flow through the structure was minimal and into the project area. There was no flow through the project structure once it was closed which prevented any oil slick access to interior marshes. There were no photographs taken at the time of the

inspection, however, there have been no changes since the previous inspection other than the closure of the structure.

c. Inspection Results

Water Control Structure

The fish gates were closed at the time of the inspection in accordance with the Operation and Maintenance Plan. The damage to the structure from the Sept 2008 Hurricanes Gustav and Ike, consisting of two missing vinyl gate stem covers, was still evident at the time of the inspection.

The operation of the structure is currently being performed by the OCPR. At the time of this report, a scope of work is being drafted to provide operations and maintenance. St Bernard Parish has been unresponsive in our efforts to contact them concerning the current operations plan, permit, and the need to amend the two documents. The Parish is also unresponsive to our requests for information concerning the flap gates they are to install on the culverts under Hwy 624.

Electronic Alarm Devices

Both devices were damaged beyond repair by the 2008 Hurricanes. The decision not to replace this equipment has been made. This will be the last report on this equipment.

d. Maintenance Conclusions

The Hopedale Hydrologic Restoration Project (PO-24) is performing as designed. The structure remains closed until further notice, but is fully operational. The need for preventative maintenance and more active participation in operations is evident. It is anticipated that a contract will be in place for operations and maintenance before the end of 2010.

e. Maintenance Recommendations

Perform preventative maintenance on a regular basis.

Immediate Repairs

- Replace two vinyl gate stem covers. This will be done in 2011 through a new maintenance contract.

Programmed Maintenance

- Continue to check gates on structure for operability.

III. Monitoring Activity

a. Monitoring Goals

The objectives of the Hopedale Hydrologic Restoration Project are three-fold: (1) to maintain and enhance existing marsh in the project area by reducing the tidal influx of higher salinity water, (2) to reduce the intensity and duration of marsh inundation, and (3) to maintain organism exchange.

The following goals will contribute to the evaluation of the above objective:

1. Maintain 99% of the pre-construction acres of vegetated wetlands over the life of the project.
2. Reduce the number and duration of flooding events.
3. Maintain or improve fisheries ingress and egress.

b. Monitoring Elements

1. Aerial Photography

To determine ratios of land to open water and land loss rates in the project area, color-infrared aerial photography (1:12,000 scale with ground controls) is being used. The photography acquired to date has been georectified, mapped and analyzed using techniques described in Steyer et al. (1995, revised 2000). Aerial photography was taken in 2000 (pre-construction), and will be taken again in 2013 and 2023 (post-construction).

2. Continuous Hydrologic Data – Salinity and Water Level

Three PO-24 continuous recorder stations (PO24-01, -03, and -05) are located within the project area (project sites) and two PO-24 recorders (PO24-02 and -04) are located outside the project area (reference sites, Figure 1). Additionally, four Coastwide Reference Monitoring System (CRMS) sites will be included in the monitoring data discussions and analyses. CRMS3800 is within the PO-24 project boundary (project site)

and three CRMS sites are located outside of the project area (CRMS4548, 4551, and 4557; reference sites). For the purposes of this report, all analyses will include data from the beginning of each data record through December 31, 2009.

Hourly water level, temperature, specific conductivity, and salinity data are collected at each site. The continuous recorder is mounted on a wooden post in open water environments with sufficient water depths to inundate the recorder year round. Each continuous recorder station is serviced every 1 to 3 months to clean and calibrate the recorder and to download the data. During processing, the data are examined for accuracy and water level data are converted to a common vertical datum in relation to the elevation of a surveyed 'mark' (nail) located on the side of each post. The data are then loaded to the OCPR database and are available for download from the CRMS website (http://www.lacoast.gov/crms2).

Salinity data have been collected hourly from June 1, 2000 to present and will continue to be collected through 2010 at all five PO-24 stations. Only two stations (PO24-02 and PO24-05) will remain active after 2010 and will continue to collect data until 2023. The CRMS sites included in this report have collected hourly salinity data from January 2008 to present and will continue to collect data until 2025.

The same 9 recorders used to collect salinity data are also used to record water level. All 9 stations are surveyed to the North American Vertical Datum (NAVD 88) to allow the data to be converted to a known elevation. Average marsh elevation was determined directly adjacent to each station at the time of establishment in 2000 except for CRMS stations which were surveyed in mid to late 2007 (Table 1). The average marsh elevation enables assessment of frequency, depth and duration of project area marsh flooding. However, PO24-02 and PO24-04 are not directly adjacent to marsh; therefore average marsh elevation is unavailable for these stations.

Table 1. Surveyed marsh surface elevation at PO-24 project and reference sites.

Station	Marsh Surface Elevation (ft; NAVD88)	Year of Active Survey
PO24-01	0.72	2000
PO24-02	NA	
PO24-03	0.82	2000
PO24-04	NA	
PO24-05	0.71	2000

CRMS3800	0.34	2007
CRMS4548	0.68	2007
CRMS4551	0.84	2007
CRMS4557	0.99	2007

3. CRMS Data Parameters

In addition to surface water level, specific conductivity, temperature, and salinity the following parameters are measured at each CRMS station in accordance to the CRMS standard operating procedures (Folse et al. 2008). These data are available and provide an opportunity to evaluate the health and ecological trajectory of the surrounding wetlands.

Soil Porewater Salinity

Soil porewater salinity readings are measured at depths of 10 cm and 30 cm using a sipper probe to aid in extracting interstitial water. Three replicates are taken at each depth during monthly servicing. Porewater salinity is a discrete measurement that does not change as rapidly as surface water salinity and is therefore a more accurate long-term indicator of salinity levels that plants are subjected to.

Soil Properties

Soil cores are taken to a depth of 24 cm, sliced into 4 cm sections, and analyzed for soil pH, soil salinity (EC), bulk density, soil moisture, percent organic matter (loss-on-ignition or LOI), and wet/dry volume. Three baseline core samples are collected from all sites within one year of site establishment. In addition to the baseline cores, soils will be sampled every 10 years for marsh sites and every 6 years for swamp sites. Cores are taken on a surface that is representative of the area (i.e., not on obvious high or low points, on clumps, or in trenasses). All core samples are analyzed according to standardized procedures developed by the Coastal Wetlands Soils Characterization Lab, Department of Agronomy & Environmental Management, and Louisiana State University (Folse et al. 2008).

Herbaceous Marsh Vegetation

There are 10 vegetation stations (plots) at each CRMS site. Vegetation transects are oriented diagonally across the 200 m^2 area, either NW to SE or NE to SW. Transects are established away from spoil banks or any type of human-induced surface alterations to

avoid biased data. Annual vegetation sampling occurs during an 8-week period on or around August 1 to September 30. Species composition and percent cover for each station are visually estimated following the Braun-Blanquet cover scale. Average heights of the vegetation and of the dominant species are also determined. Species names are consistent with the standard botanical names used in the USDA Plants Database (available at http://plants.usda.gov).

A Floristic Quality Index (FQI) has been developed by the USGS for each CRMS site using the annual species composition and percent cover data. The FQI is used to evaluate the quality of a wetland based on its species composition where invasive plant species and those that are opportunistic users of disturbed sites get low scores and species that are indicative of vigorous coastal wetland communities get high scores. All of the species at a site contribute to the final FQI score scaled from 0 to 100. Details of the FQI calculations can be found online at http://www.lacoast.gov/crms2/dataDescr.aspx (Cretini et al. 2009).

Marsh Surface Elevation Change

The rod-surface elevation table (RSET) technique developed by Cahoon et al. (2002a and 2002b) is used to measure changes in sediment elevation over time relative to a fixed subsurface datum. Four foot lengths of stainless steel benchmark rod are driven through the root zone, the organic matter, and any soft underlying materials until refusal is encountered by a driving force on the rod. The rod remains approximately 2 ft above the marsh surface and is stabilized by a three foot deep, six inch diameter pipe that is cemented at the surface. A custom-made stainless steel collar is permanently attached to the rod to provide a constant horizontal reference plane for long-term repeatability as the table remains fixed for each sampling period.

Data collection occurs by attaching a custom-made RSET table to the collar, leveling the instrument, and lowering 9 fiberglass pins through the table to the marsh surface. The height (measured in millimeters) that each pin extends above the table is used to calculate vertical changes of the marsh surface over time. The table is repositioned to measure the marsh surface at four 90° angles, providing 36 measurements per station. Using previously collected data, the rate of change can be calculated to provide a measure of status and trends with respect to elevation changes occurring between the wetland surface and the bottom of the stainless steel rod. RSET measurements occur twice per year (late

winter/early spring and late summer/early autumn) on the same day that soil accretion data are collected.

Vertical Accretion

Vertical accretion/loss is measured using white feldspar clay, which is easily distinguishable from the natural substrate, as an artificial marker horizon. The feldspar clay is evenly sprinkled on the marsh surface in sets of 3 stations (plots) every 2 years. Stations are sampled repeatedly over time to determine the rate of soil accumulation/removal over the marker horizon using a cryogenic coring technique (Cahoon et al. 1996). After establishment, station sets are sampled twice per year (late winter/early spring and late summer/early autumn) for 2 years (short-term), then are transitioned to sampling every 1.5 years thereafter (long-term).

4. Data Availability

CWPPRA project data and CRMS data collected for each parameter are available to the public for download on-line at the CRMS website (http://www.lacoast.gov/crms2).

c. Monitoring Results and Discussion

1. Aerial Photography

Aerial photography obtained in 2000 (pre-construction) has been analyzed and is presented in Figure 2. Based on the analysis, the project area is approximately 74% land (3463 acres) and 26% water (1193 acres). Additional photography will be obtained in 2012 which will be analyzed to determine change rates within the project boundary. This information will be used to evaluate the effectiveness of the project related to the first stated project goal.

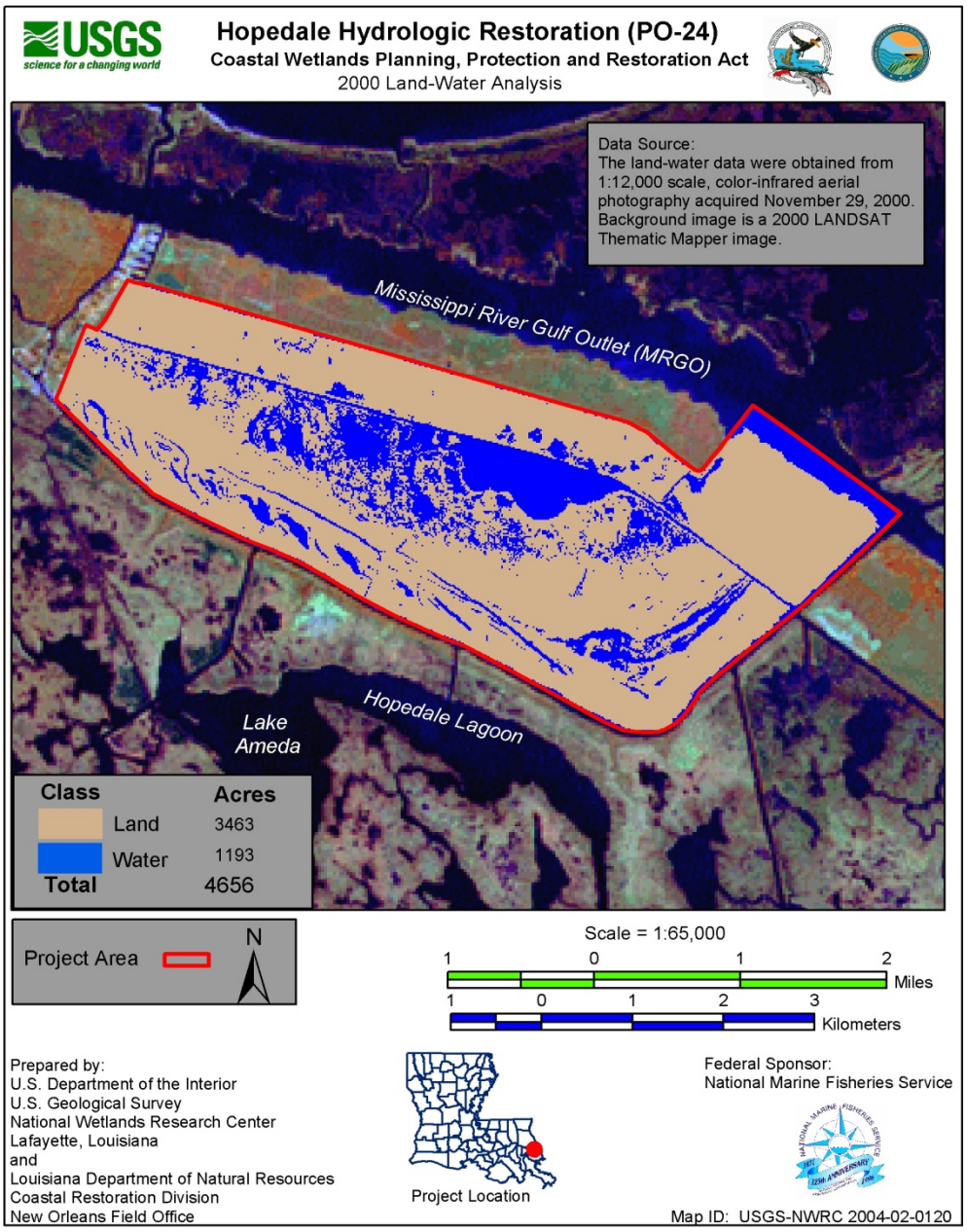


Figure 2. Land-Water analysis from 2000 aerial photography for the Hopedale Hydrologic Restoration (PO-24) Project.

2. Salinity

The Back Dike Borrow Canal, which connects Bayou La Loutre to the project area, was completely blocked during construction to allow for structure placement, thus stopping water exchange. Data collected during the construction period (10 January 2004 – 30 November 2004; Table 2) were removed from the salinity data set for analyses, but are presented in the time series graphs (Figures 3 and 4). Hourly data were averaged to obtain mean weekly salinity readings which were used for all subsequent statistical analyses. Mean weekly observations were used to reduce the effects of diurnal tides and meteorological events in the data.

The initial deployment of the Hopedale Hydrologic Restoration (PO-24) project continuous recorders occurred during a severe drought. The drought affected southeast Louisiana from August 1999 to December 2000 during which time widespread dieback of marsh vegetation occurred throughout Louisiana's coastal zone (locally known as the Brown Marsh Dieback). Figures 3 and 4 depict salinity signals over the 10-year data record. All stations recorded elevated salinity levels during the beginning months of data collection in response to this drought with salinity values registering up to 10 ppt greater than normal conditions. Visual observation of weekly means indicate that project and reference stations tracked one another fairly closely, even after completion of construction in November 2004. Salinity levels in the first half of 2008 were the lowest in our period of record. During this same time period the Bonnet Carré spillway structure was opened at approximately half-capacity for 31 days due to increasing Mississippi River water levels. Freshwater from the spillway opening was capable of entering the MRGO from the north or south and may have influenced the project area during this time period.

Figures 5 through 7 compare salinity data for the period of record containing CRMS data (beginning Jan 2008). All monitoring stations have a similar signature with the exception of CRMS4557. Beginning in mid-2009 salinity values diverge from surrounding sites and increase by up to 10 ppt (Figure 7). This time period coincides with the closure of the MRGO navigation channel which may have influenced site 4557 as it is southeast of the closure structure. Salinity signature at PO24-05 is most similar to the project CRMS station 3800. The differences in the station data in reference to CRMS3800 may be useful in decision making after 2010 when some stations are removed.

Figures 8 through 10 further illustrate the similarities between sites when the data are summarized into seasonal means. Before the closure of the MRGO channel, the close

proximity of the project to the MRGO resulted in salinity incursions during tropical events, or even periods of sustained strong east winds, which can be identified by spikes in Figures 3 through 7. Unfortunately, during the strongest storm to affect the area over the period of data collection, Hurricane Katrina, all stations were flooded or destroyed resulting in a loss of most data for this event. In fact, salinity effects from storm surges are difficult to pin-point due to data losses during these high water events. However, the spikes from these meteorological events were short-lived compared to the increase in salinity associated with the drought at the beginning of data collection.

Figure 11 shows that the mean weekly salinity concentrations at each PO-24 continuous recorder have significantly decreased between the pre- and post- construction period. Although all PO-24 stations showed a significant statistical change in salinity, the level of decrease was very small compared to the target salinity range for this marsh type (Mesohaline, 5-18 ppt) suggesting that a change in marsh community is not likely. Floristic Quality Index (discussed in greater detail below) indicates that indeed no changes in marsh community have occurred in the area since 2007. CRMS 3800 does show a decrease in FQI for 2008 but the dominant species remains *Spartina patens* and the small decline is likely a result of Hurricane Gustav.

To test the interaction between project and reference sites in pre-construction and post-construction time periods, non-parametric Before After Control Impact (BACI) paired series analyses were performed following OCPR analysis protocols. For this analysis, sondes were "paired" based on the field design. Differences were calculated by subtracting mean weekly salinity at the impacted (project) site from the control (reference) site (difference = reference – project). A 2-sample median test (a non-parametric analog of a 2-sample t-test) was used to compare the site differences before and after construction. The test is a non-parametric One-way ANOVA with a median test of Chi Square values. The statistical model depends on simultaneous measurements among the paired sondes, therefore, only weeks in which there were data available to calculate differences were used in the analysis. This analysis was run using JMP 5.0.1 statistical software.

Results of the BACI paired analysis for PO24-01 (project) and PO24-02 (reference) indicate a significant interaction with PO24-01 decreasing in salinity compared to PO24-02 over time by approximately 1 ppt. This shows up as lines out of parallel in Figure 12. The level of decreased salinity was very small compared to the target salinity range for this marsh type (mesohaline, 5-18 ppt) suggesting that a change in marsh community is

not likely. There were also significant interactions between PO24-03 and PO24-04 as well as PO24-01 and PO24-02 (Figure 12) with both project sites showing a decrease in salinity post-construction. On average, the salinity within the project area decreased by less than 0.5 ppt from what would be expected if the project had no impact.

Table 2. Significant events and dates.

Event Description	Date
Initial Brown Marsh Event	Spring 2000
Tropical Storm Isidore	26-Sep-02
Hurricane Lili	3-Oct-02
Hurricane Ivan	16-Sep-04
Tropical Storm Ivan	23-Sep-04
PO-24 Control Structure Construction Begins	10-Jan-04
PO-24 Control Structure Construction Completion	30-Nov-04
Hurricane Cindy	6-Jul-05
Hurricane Katrina	29-Aug-05
Hurricane Rita	24-Sep-05
Hurricane Humberto	13-Sep-07
Bonnet Carre Spillway Opening (160 bays open 31 days)	11-Apr-08
Hurricane Gustav	1-Sep-08
Hurricane Ike	13-Sep-08
MRGO Closure	January – July 2009

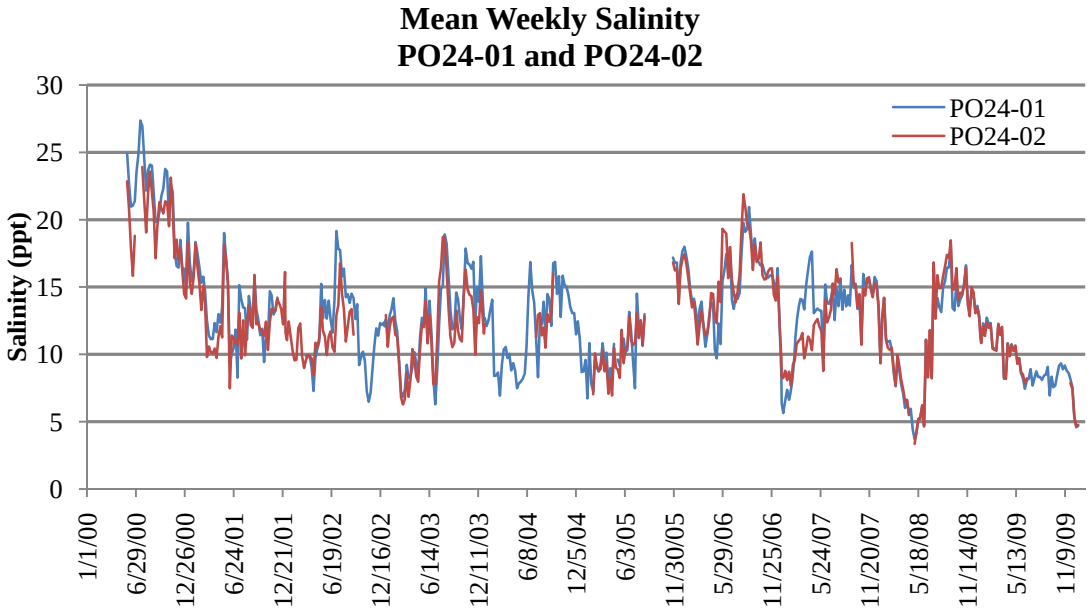


Figure 03. Mean weekly salinity for project station PO24-01 and reference station PO24-02 for the Hopedale Hydrologic Restoration project.

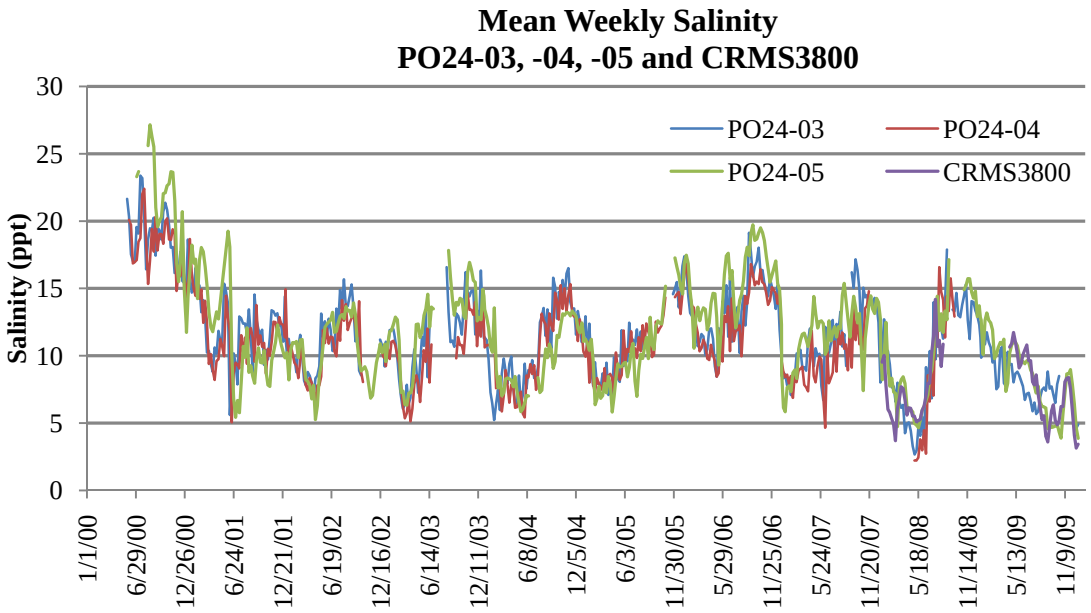


Figure 04. Mean weekly salinity for project stations PO24-03, PO24-05, and CRMS3800 and reference station PO24-04 for the Hopedale Hydrologic Restoration project.

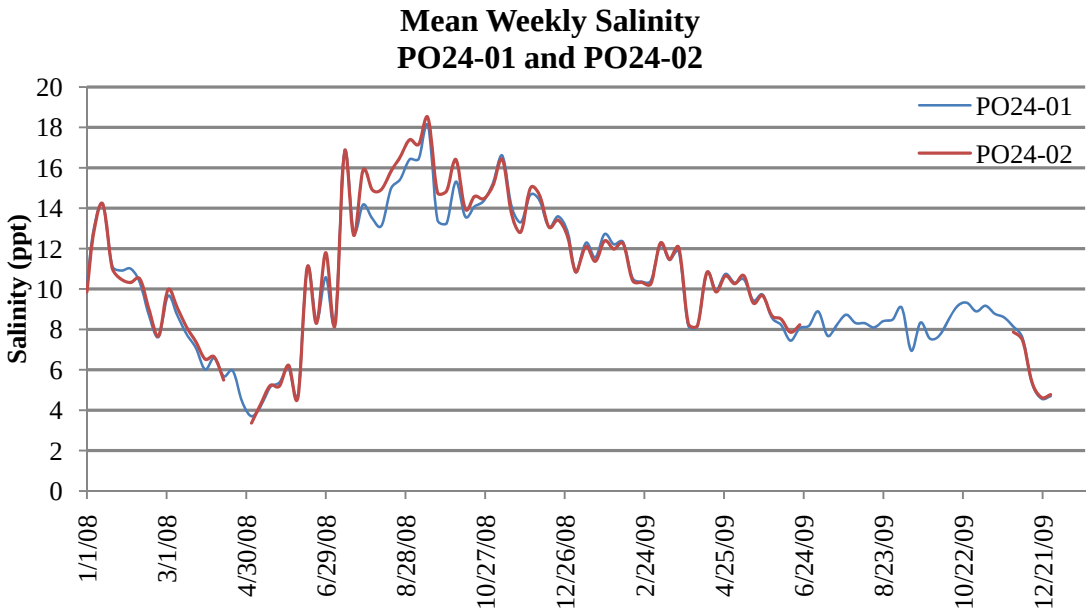


Figure 05. Mean weekly salinity for project station PO24-01 and reference station PO24-02 for the Hopedale Hydrologic Restoration project.

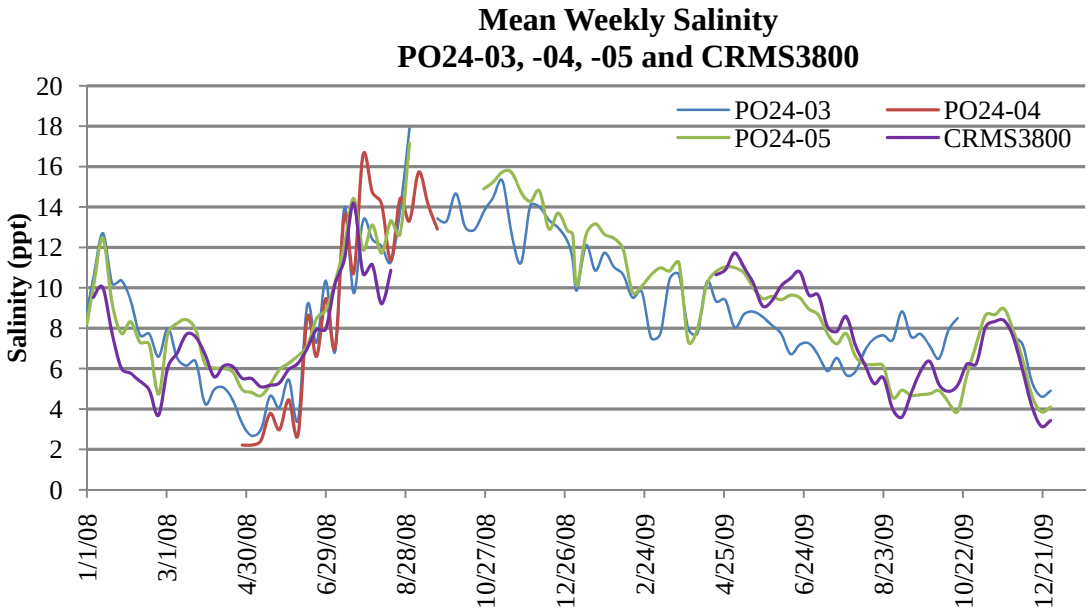


Figure 06. Mean weekly salinity for project stations PO24-03, PO24-05, and CRMS3800 and reference station PO24-04 for the Hopedale Hydrologic Restoration project.

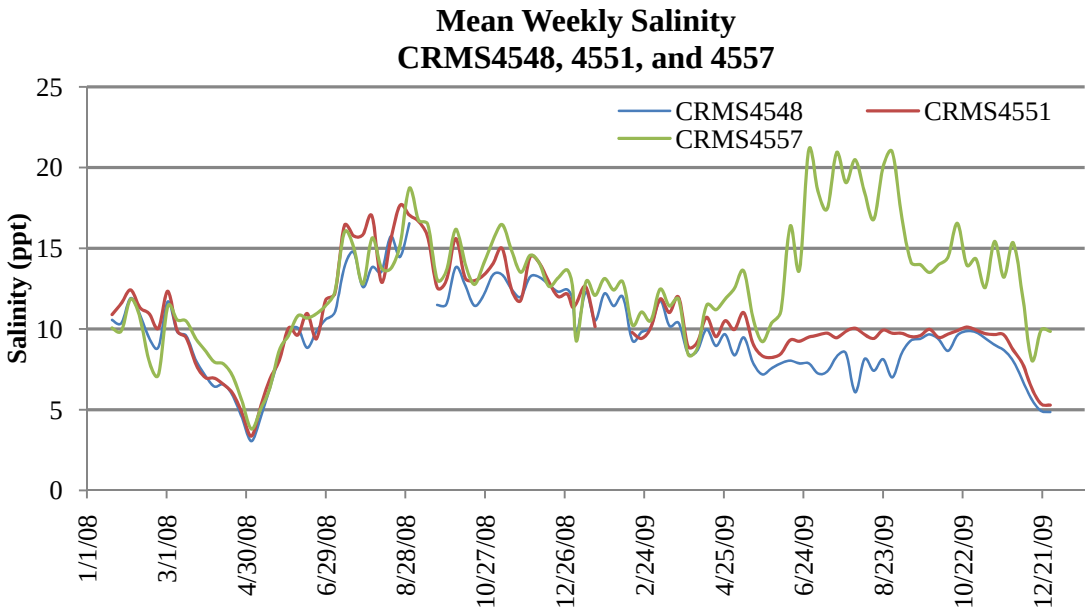


Figure 07. Mean weekly salinity for CRMS stations CRMS4548, CRMS4551, and CRMS4557 near the Hopedale Hydrologic Restoration project.

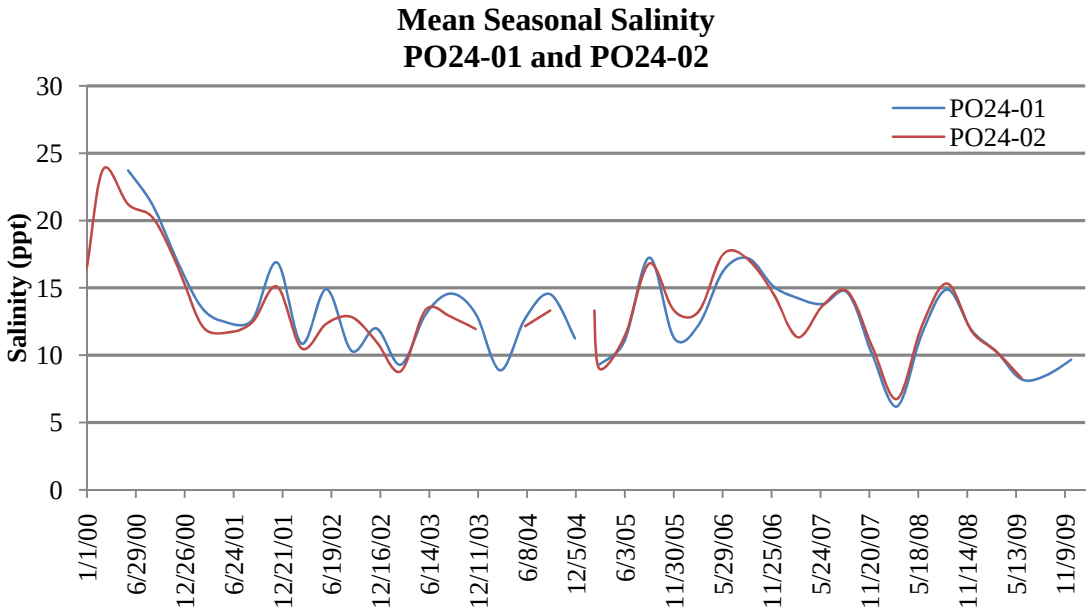


Figure 08. Mean seasonal salinity for project station PO24-01 and reference station PO24-02 for the Hopedale Hydrologic Restoration project.

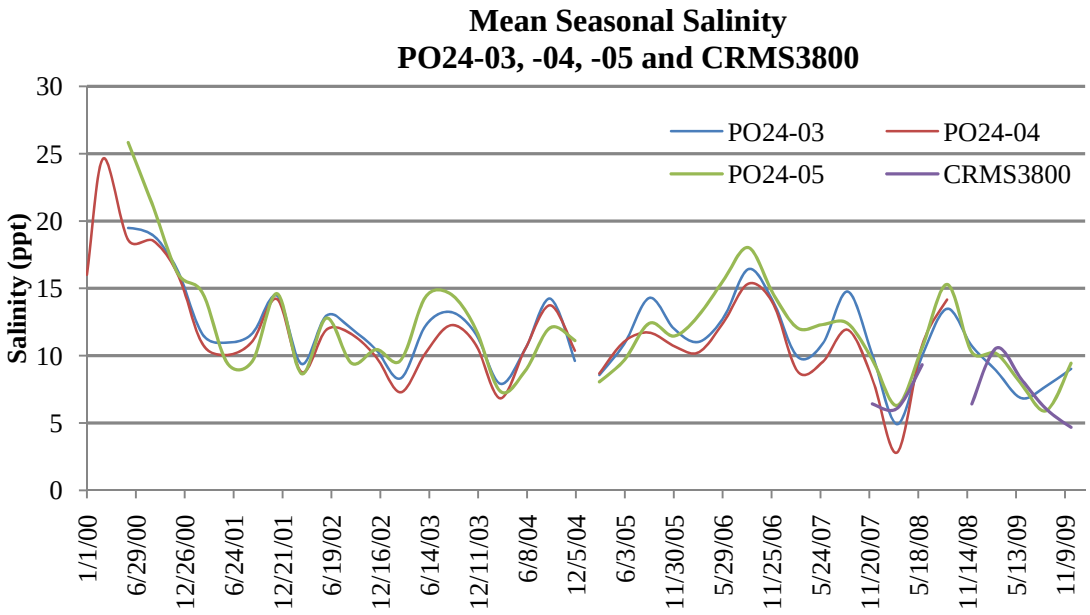


Figure 09. Mean seasonal salinity for project stations PO24-03, PO24-05, and CRMS3800 and reference station PO24-04 for the Hopedale Hydrologic Restoration project.

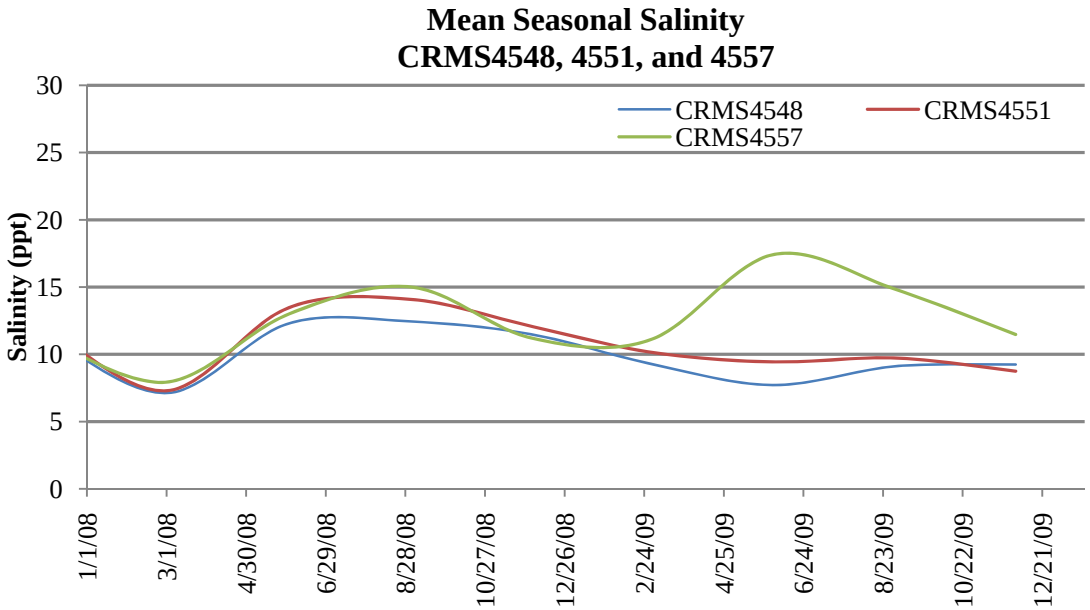


Figure 10. Mean seasonal salinity for CRMS stations CRMS4548, CRMS4551, and CRMS4557 near the Hopedale Hydrologic Restoration project.

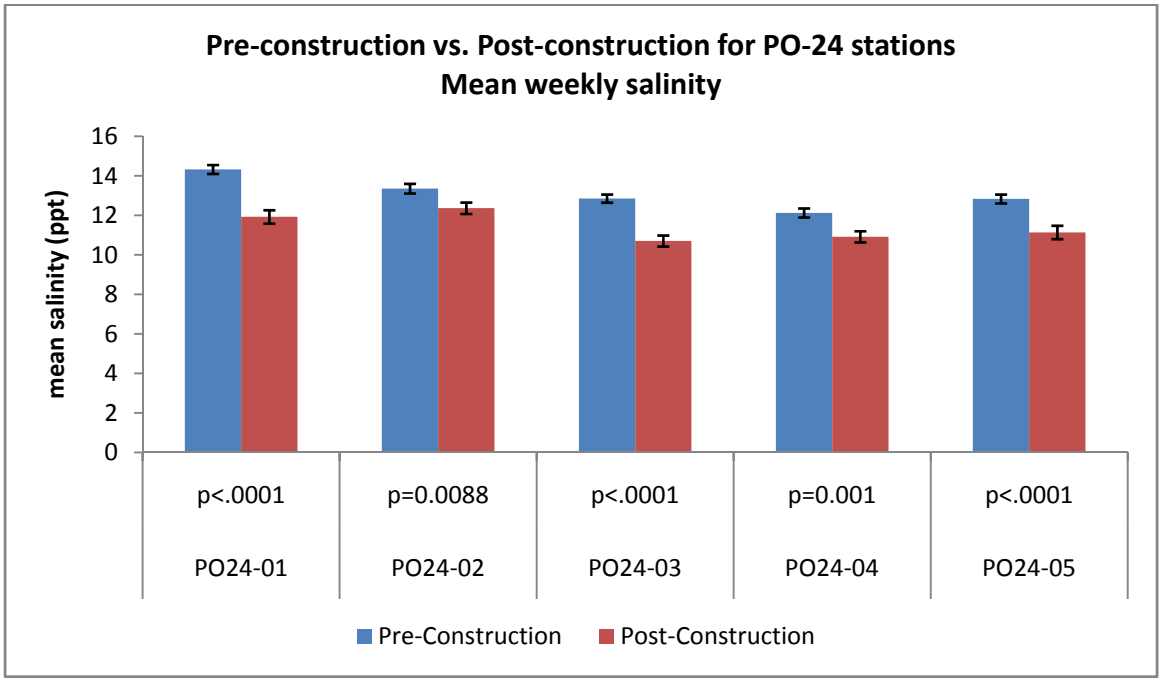


Figure 11. Average of mean weekly salinity for the pre- and post-construction periods of the Hopedale Hydrologic Restoration project. Statistics computed using ANOVA. Error bars represent the standard error of the mean.

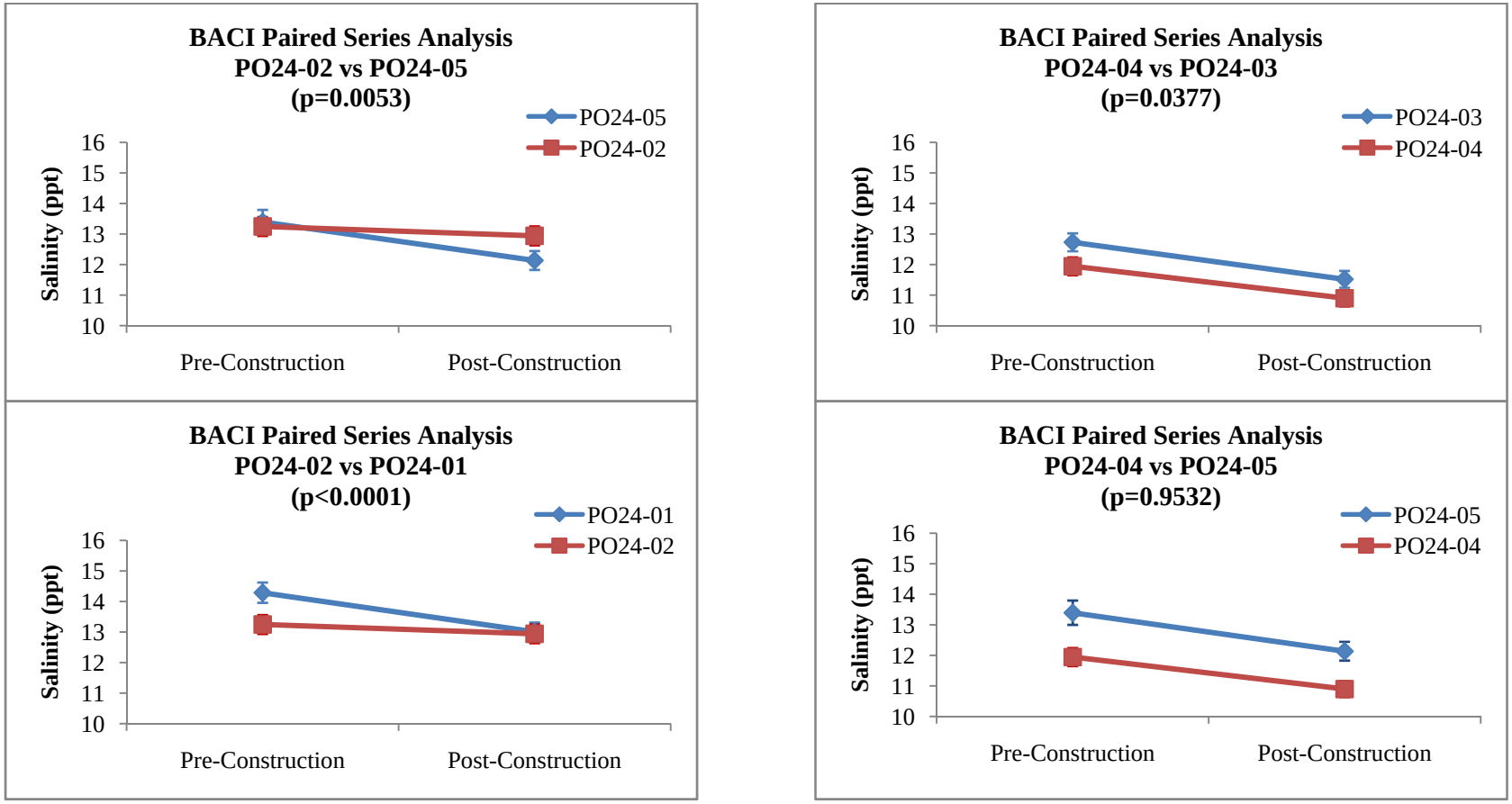


Figure 12. BACI paired series analysis graphs for salinity.

3. Water Level

The Back Dike Borrow Canal, which connects Bayou La Loutre to the project area, was completely blocked during construction to allow for structure placement, thus stopping water exchange. Data collected during the construction period (10 January 2004 – 30 November 2004) were removed from the water level data set for analysis, but are presented in the time series graphs. Hourly data were averaged to obtain mean weekly water level readings which were used for all subsequent statistical analyses. Mean weekly observations were used to reduce the effects of diurnal tides and meteorological events in the data.

Visual observation of mean weekly water level shows project stations maintaining lower water elevations than reference stations after construction was completed in November 2004 (Figures 13 through 17). This trend is also apparent when the data are presented seasonally (Figures 18 through 20).

Figure 21 shows a significant decrease in mean water levels post-construction in project sites PO24-01 and -05 with decreases of approximately 0.3 feet. Station PO24-03 showed a slight decrease in water level but was not significant. This is reasonable considering its location within the project area. Station 03 is located in a small unnamed bayou on the south side of the Bayou La Loutre ridge, near the south central boundary of the project area. The connection of this small bayou with Bayou La Loutre is through three 36" non-gated culverts which run under Hwy. 624. These open culverts allow water to flow in and out of the project area freely, as opposed to the structure near station PO24-01 which only allows water out.

Reference stations PO24-02 and -04 showed increases in mean water level after the completion of construction (Figure 21), however, only station 02 was significant. Analysis of CRMS reference stations (sites 4548, 4551, and 4557) and PO24-05 indicate that water levels inside the project area were lower than those outside of the project boundaries (Figure 22).

To test the interaction between project and reference sites in pre-construction and post-construction time periods, mean weekly water level measurements were analyzed by the same method as salinity data described previously. Results of the paired sites were significant for all comparisons (Figure 23) with water levels approximately 0.2 to 0.4 feet lower than what would be expected if the project had no impact. When averaged, project

site water levels decreased from 0.69 ft to 0.46 ft (NAVD88) while reference site water levels increased from 0.58 ft to 0.72 ft (NAVD88) between pre- and post-construction.

Analysis of the frequency and depth of flooding at PO-24 project stations indicate that the number of flooding events generally decreased post-construction as well, with a few exceptions (Figure 24). For instance, PO24-03 flooding increased post-construction at the 0-0.25 ft category which is likely a result of water stacking up against the ridge as water moves out of the project area through the culvert. The PO24-02 reference site shows increases in the number of flooding events or no change for all depth categories. It should be noted that the post-construction period had a data record approximately one year longer than the pre-construction period from which flooding events were calculated. Table 3 shows that the percentage of weeks flooded at individual project sites decreased from 2-25% after construction while the PO24-02 reference marsh was flooded 5% more often that it was during the pre-construction period, suggesting the project is having a positive effect on water levels and meeting target goals. Site PO24-03 had a more modest reduction in flooding since it is located near an open culvert which allows water to flow freely.

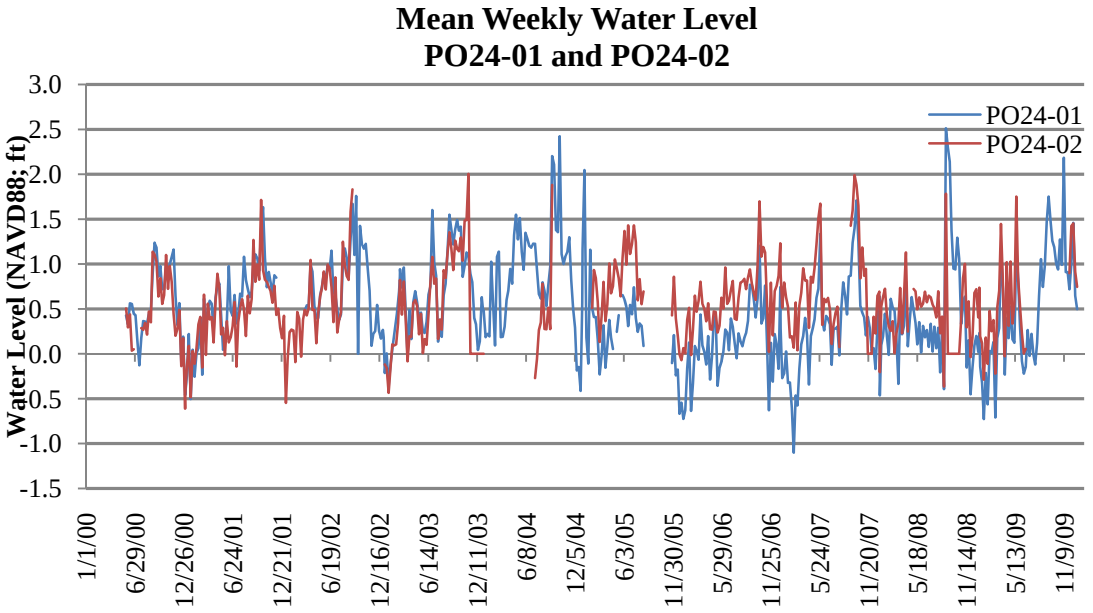


Figure 13. Mean weekly water level for project station PO24-01 and reference station PO24-02 for the Hopedale Hydrologic Restoration project.

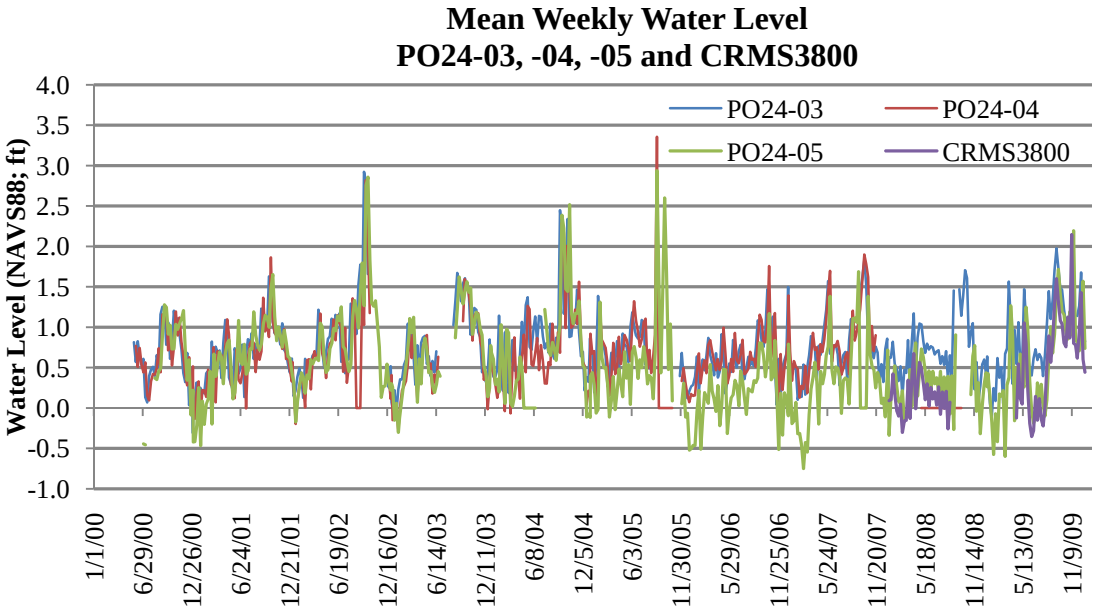


Figure 14. Mean weekly water level for project stations PO24-03 & 05, CRMS3800 and reference station PO24-04 for the Hopedale Hydrologic Restoration project.

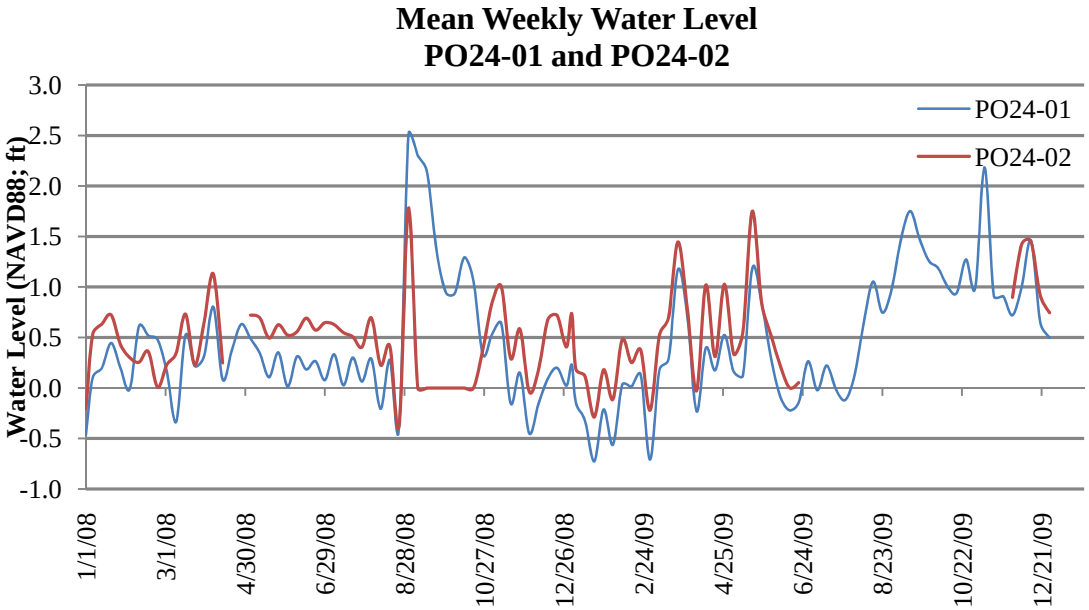


Figure 15. Mean weekly water level for project station PO24-01 and reference station PO24-02 for the Hopedale Hydrologic Restoration project.

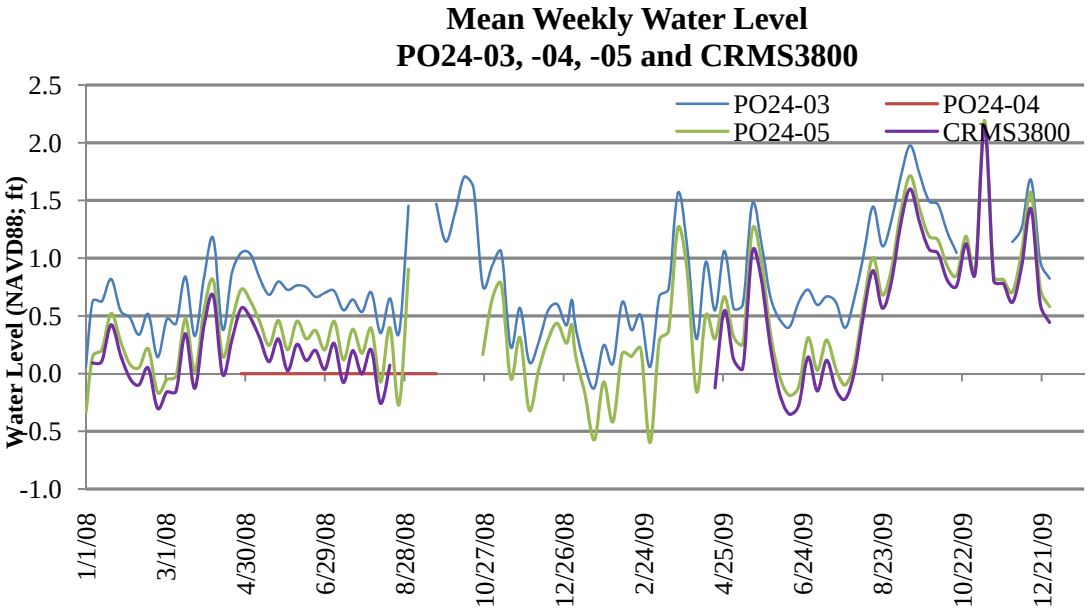


Figure 16. Mean weekly water level for project stations PO24-03 & 05, CRMS3800 and reference station PO24-04 for the Hopedale Hydrologic Restoration project.

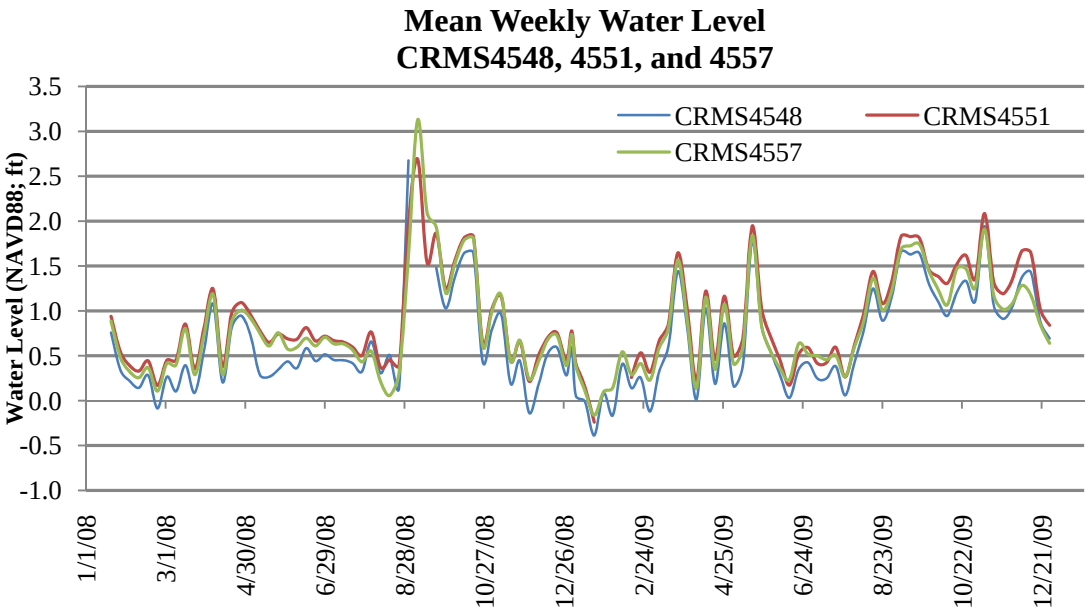


Figure 17. Mean weekly water level for CRMS stations CRMS4548, CRMS4551, and CRMS4557 near the Hopedale Hydrologic Restoration project.

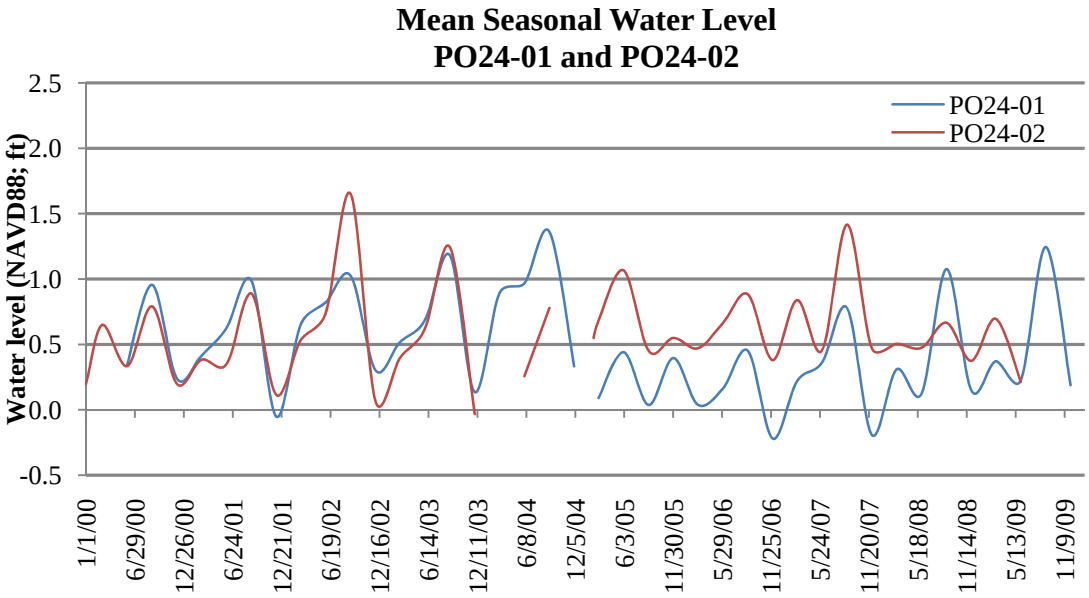


Figure 18. Mean seasonal water level for project station PO24-01 and reference station PO24-02 for the Hopedale Hydrologic Restoration project.

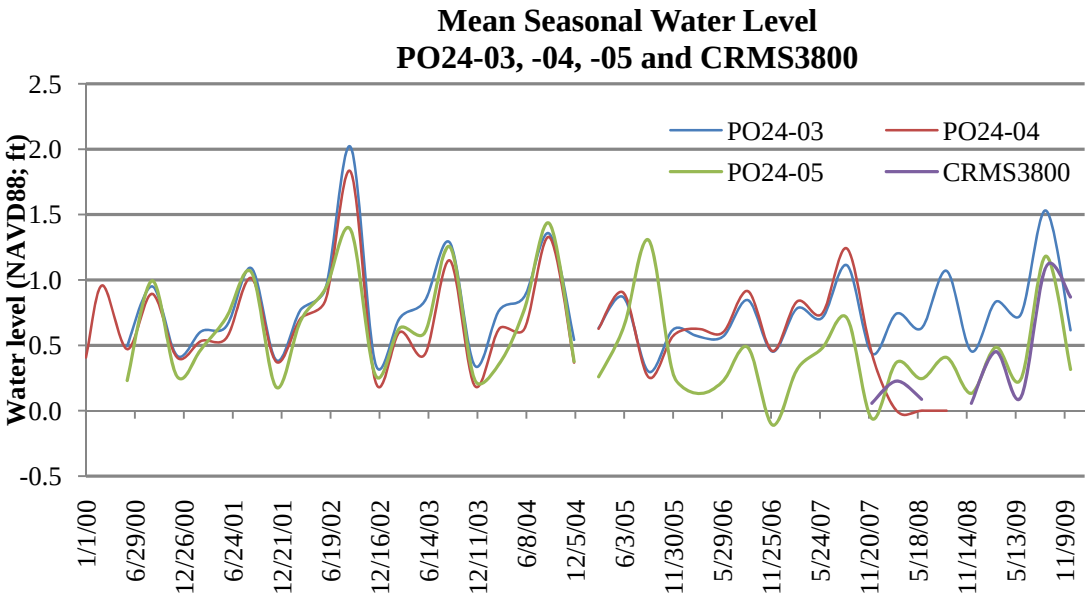


Figure 19. Mean seasonal water level for project station PO24-03, PO24-05, CRMS3800 and reference station PO24-04 for the Hopedale Hydrologic Restoration project.

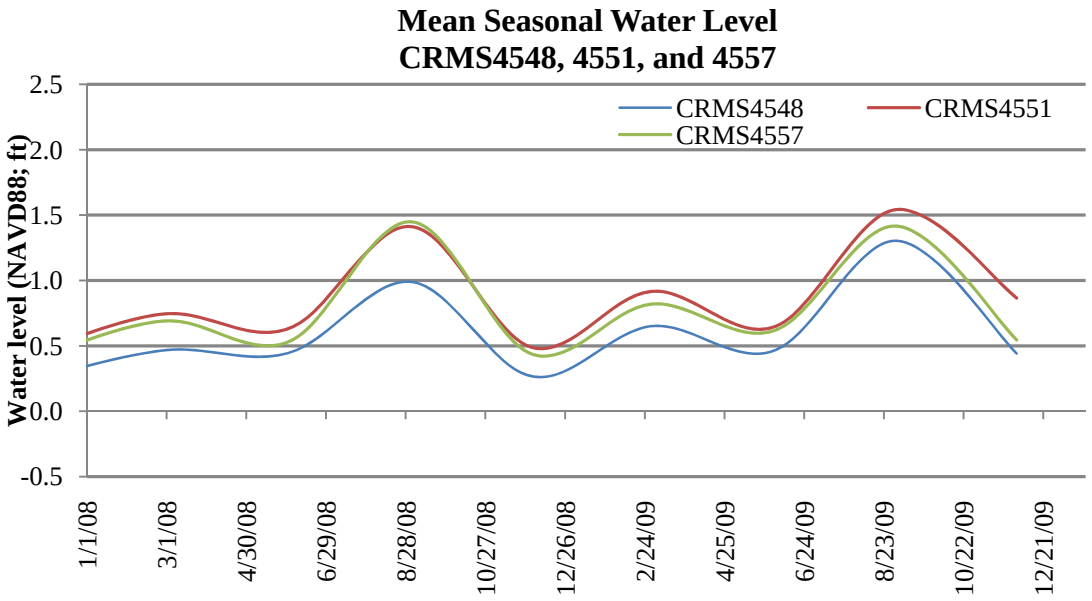


Figure 20. Mean seasonal water level for CRMS stations CRMS4548, 4551 and CRMS 4557 near the Hopedale Hydrologic Restoration project.

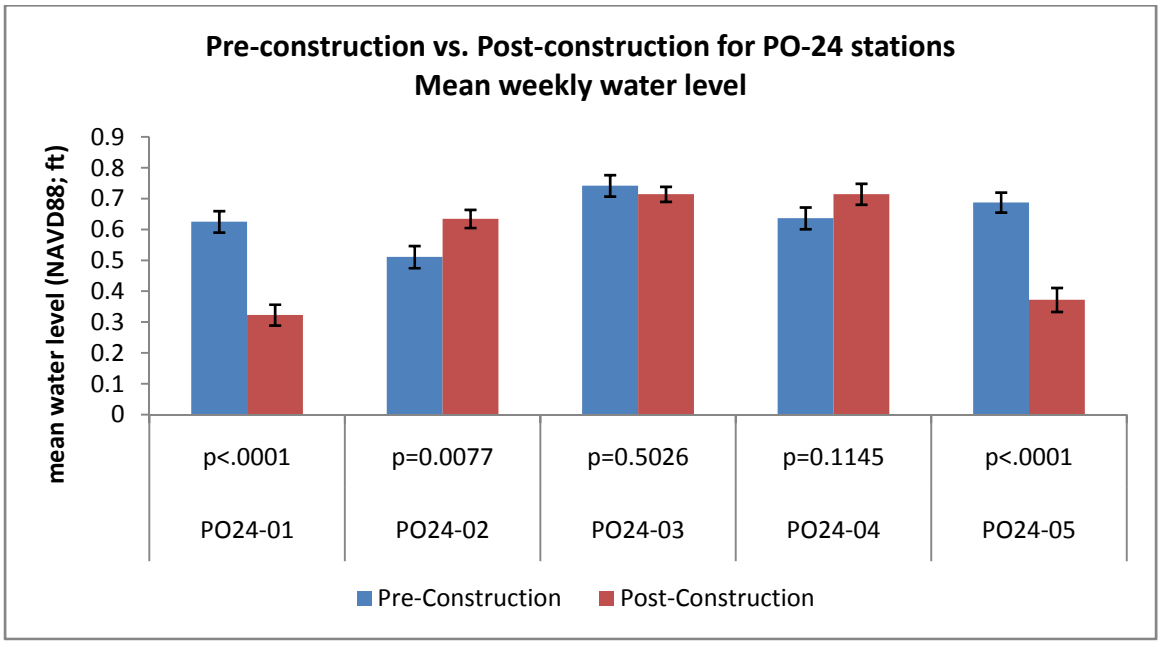


Figure 21. Average of mean weekly water level for the pre- and post-construction periods of the Hopedale Hydrologic Restoration project. Statistics computed using ANOVA.

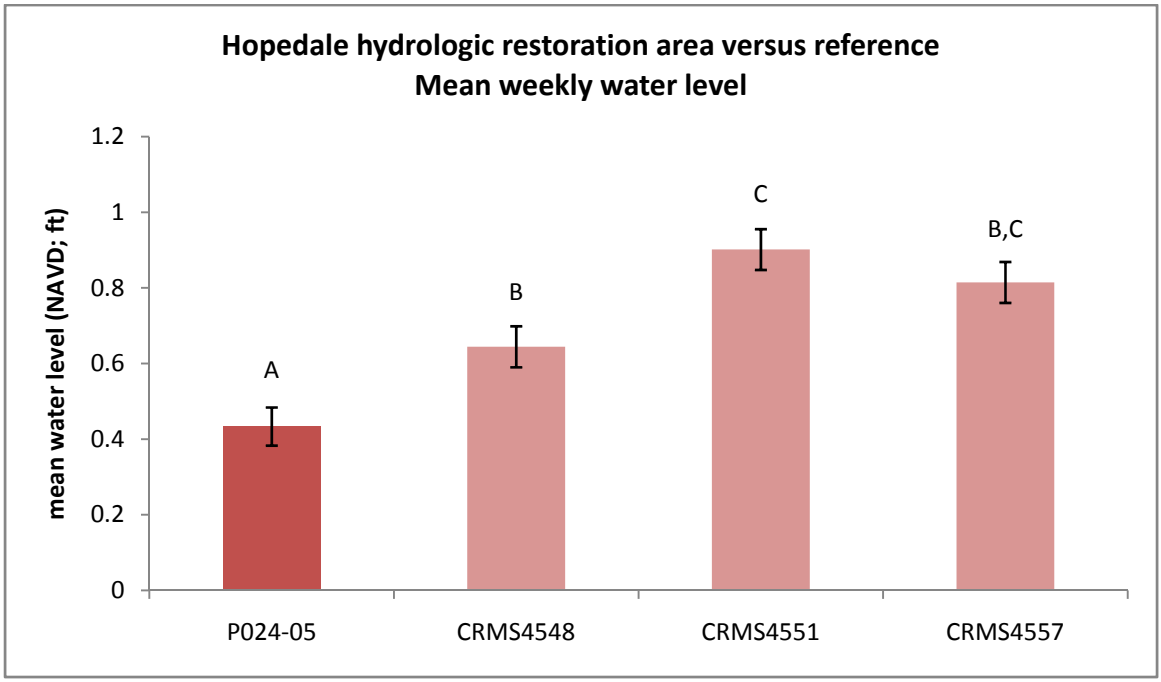
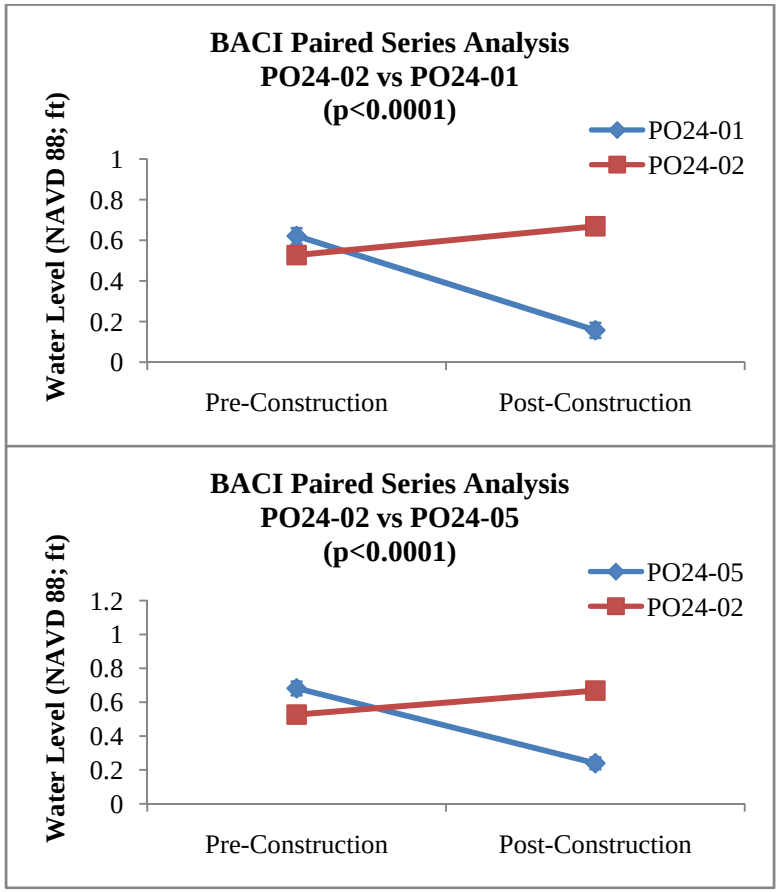


Figure 22. Average of mean weekly water level for PO24-05 and reference CRMS stations. Statistics computed using ANOVA. Different letters indicate significant difference.

Table 3. Percentage of weeks flooded pre and post construction for each station.

	Percent of Weeks Flooded		
Station ID	**Pre Construction**	**Post Construction**	**Station Classification**
PO24-01	33%	18%	Project
PO24-02*	no data	no data	Reference
PO24-03	31%	29%	Project
PO24-04*	no data	no data	Reference
PO24-05	40%	17%	Project
CRMS3800	no data	29%	Project
CRMS4548	no data	39%	Reference
CRMS4551	no data	46%	Reference
CRMS4557	no data	33%	Reference

***site not surveyed for marsh elevation**



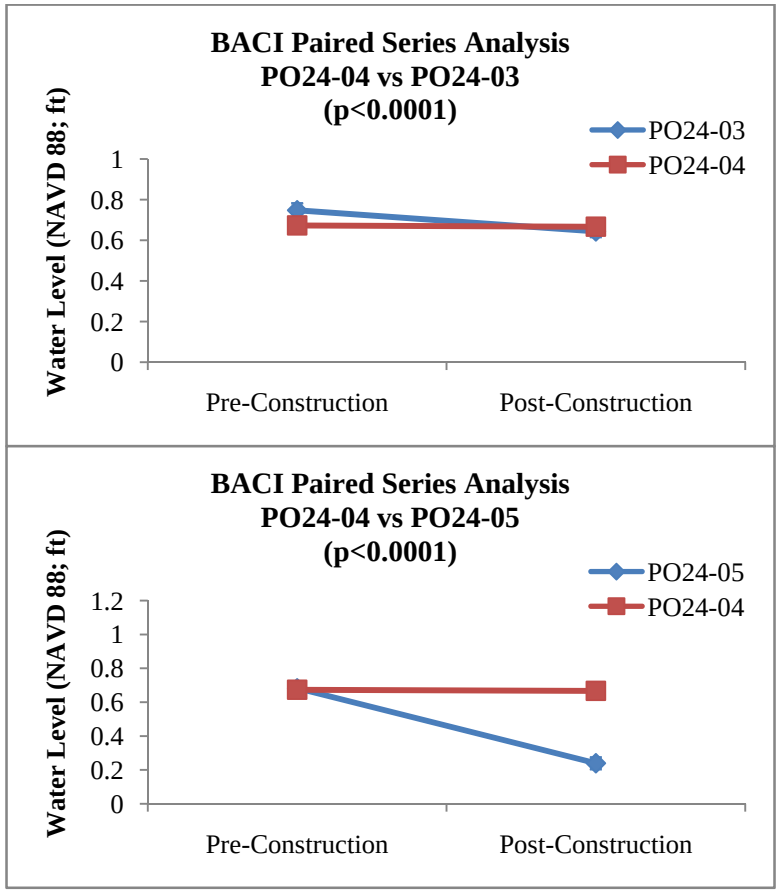


Figure 23. BACI paired series analysis graphs for water level.

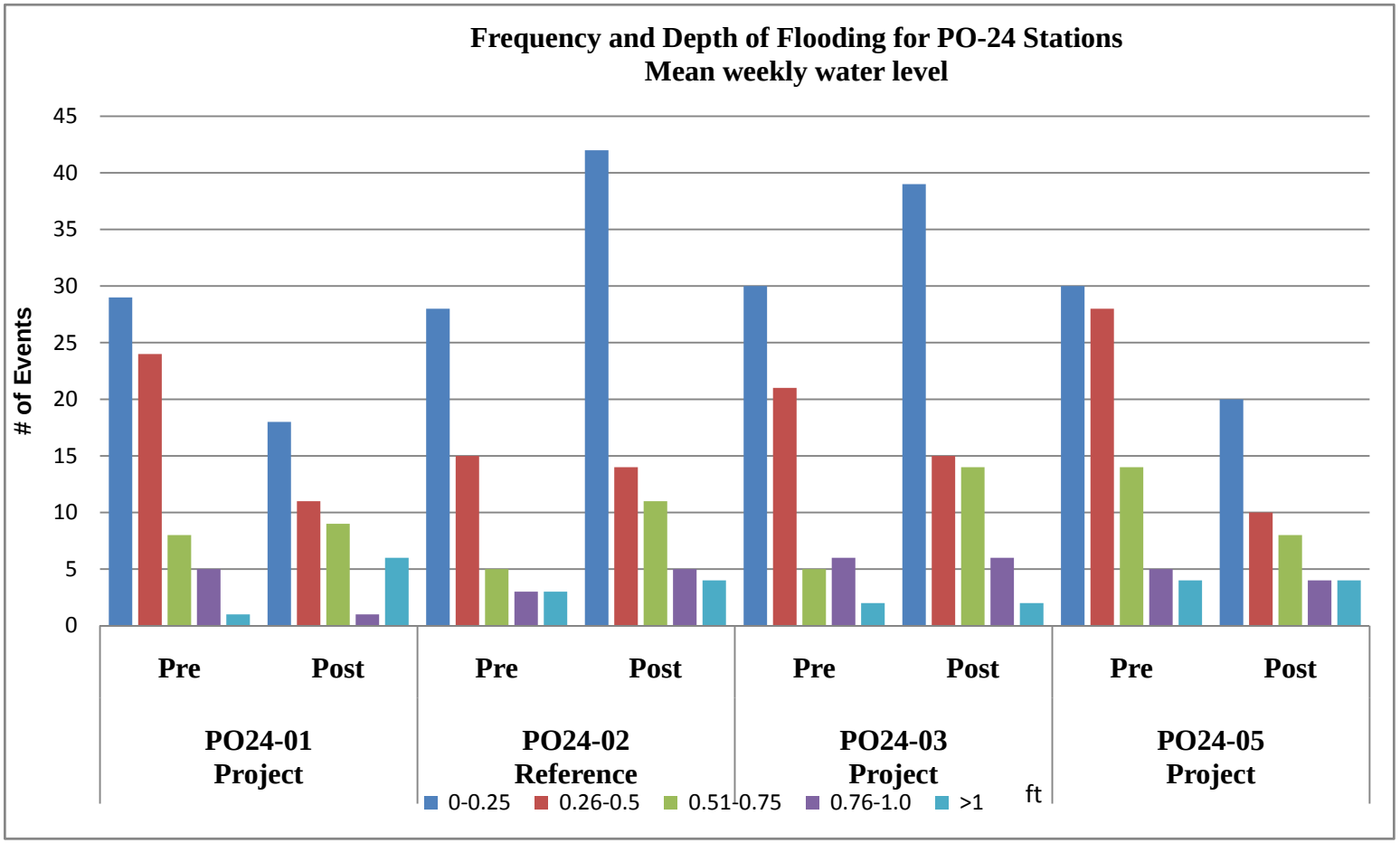


Figure 24. Frequency and depth of flooding for project stations in the Hopedale Hydrologic Restoration project.

4. CRMS Data Parameters

Soil Porewater Salinity

Soil porewater salinities were compared at all four CRMS sites over the entire data record (Figures 25-28). Each of the sites displayed fairly typical trends for soil porewater readings in that the samples at greater depth (30 cm) contained higher salt concentrations on a regular basis. However, following an inundation event containing higher salinity water, samples taken at shallower depths (10 cm) would often surpass the deeper sample (30 cm) values. This scenario is difficult to capture because the dominant plants in the Mesohaline community (*Spartina patens* and *Spartina alterniflora*) seem to assimilate salt rather quickly (excreting large amounts of salt on leaves).

Comparing CRMS3800 to the other three CRMS sites outside of the project area, the difference between the 10 cm and 30 cm readings is consistently greater at CRMS3800 and the 30 cm values stay elevated throughout most of the data record. Salinities at the 30 cm depth are often double the open water salinity readings taken via the continuous recorder which may be a potential stressor to the plants within the project area. Porewater salinities are fairly consistent at all four CRMS sites but it should be noted that CRMS3800 is classified as a brackish marsh and the other sites outside of the project area are classified as salt marshes which are more tolerant of higher salinities. In fact, the plant community is more robust and slightly different outside of the project area while the plant community inside the project area is stressed and fragmented.

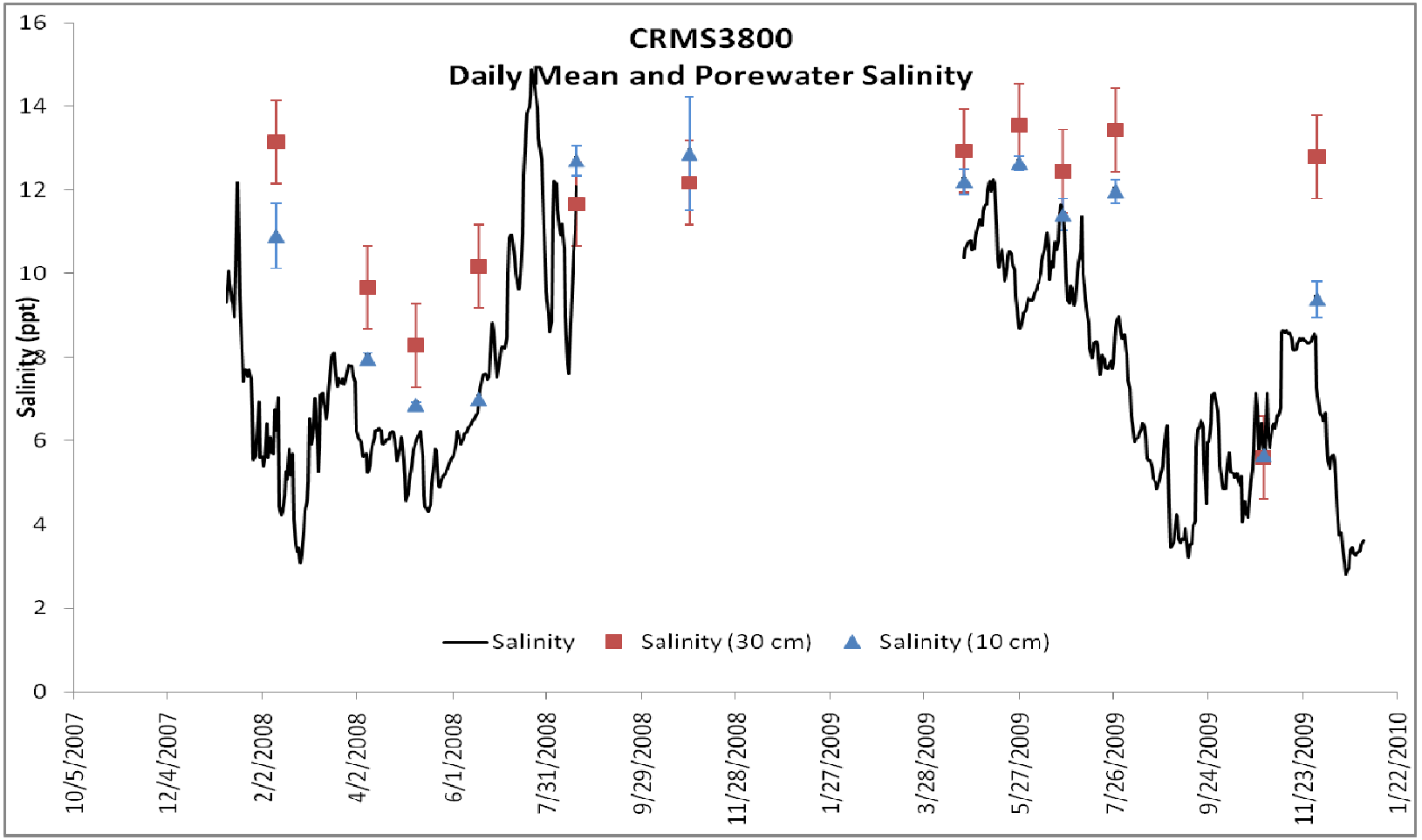


Figure 25. Daily mean salinity and porewater salinity at CRMS3800. Error bars represent standard deviations.

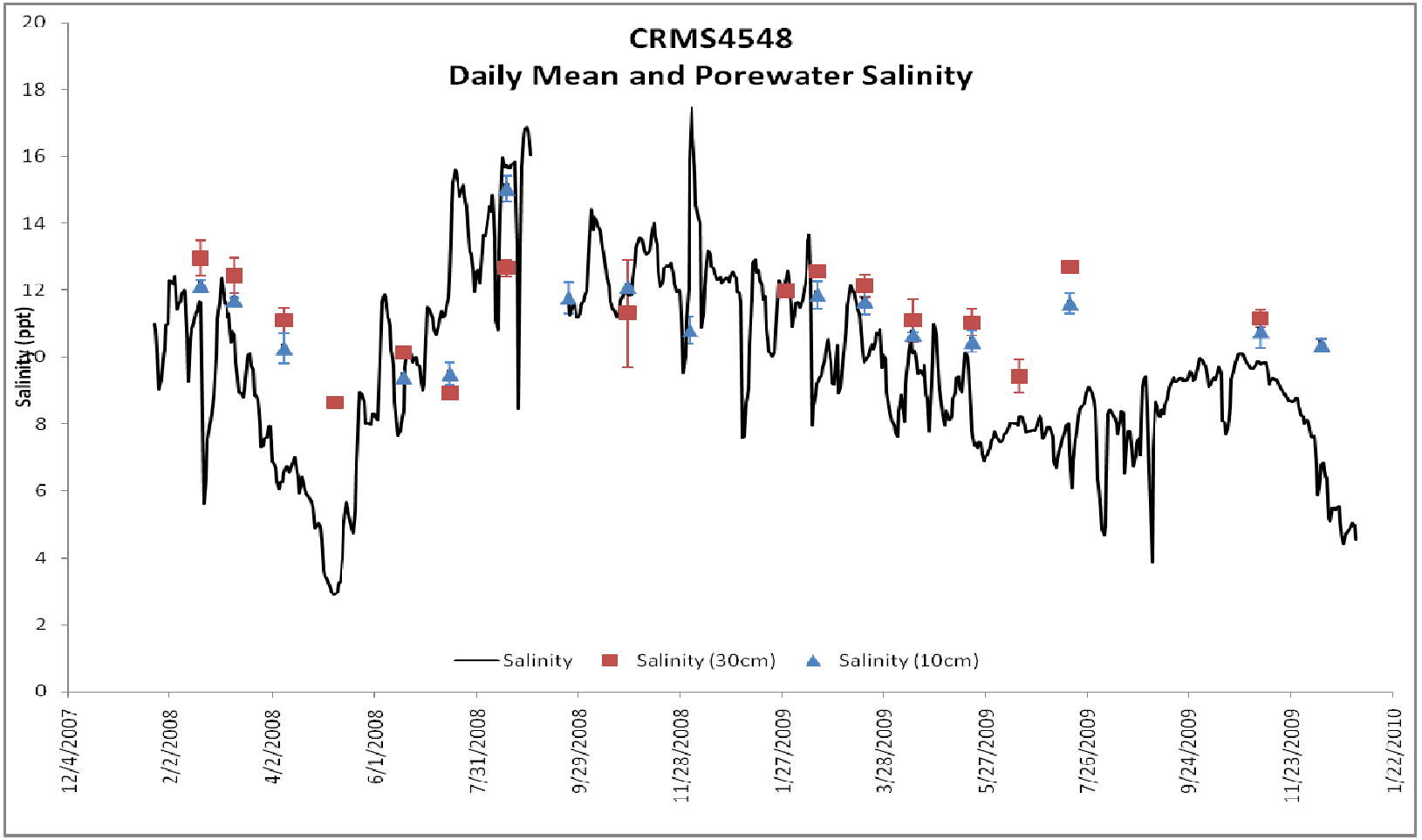


Figure 26. Daily mean salinity and porewater salinity at CRMS4548. Error bars represent standard deviations.

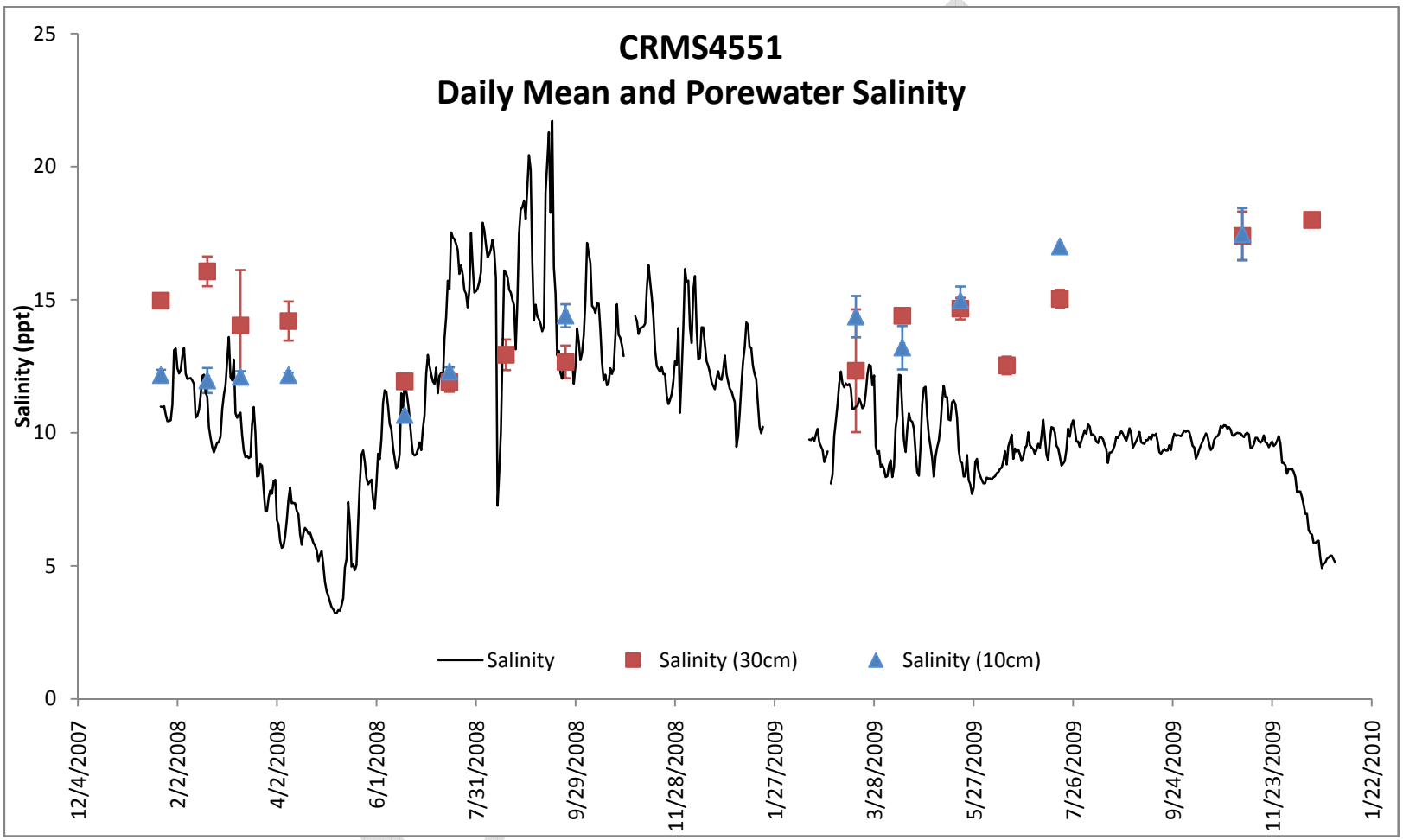


Figure 27. Daily mean salinity and porewater salinity at CRMS4551. Error bars represent standard deviations.

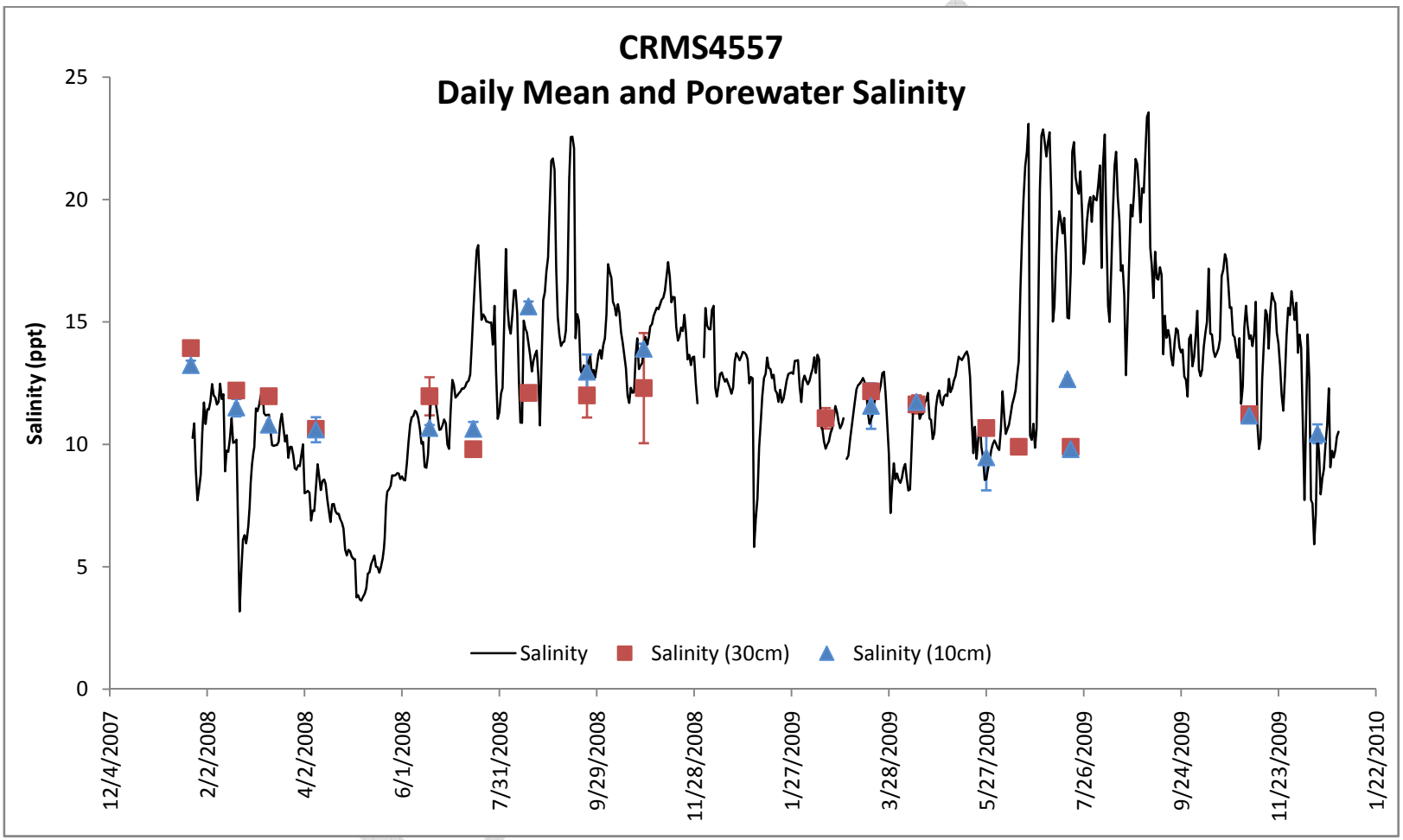


Figure 28. Daily mean salinity and porewater salinity at CRMS4557. Error bars represent standard deviations.

Soil Properties

Soil bulk density and percent organic matter were compared at all four CRMS sites (Figures 29-36). In general, the soils outside of the project area had higher bulk densities than inside the project area for all sampling depths, with the exception of CRMS4557 which was a somewhat similar to CRMS3800. Bulk density at CRMS4548 is fairly high, ranging from approximately 0.5 to 0.6 g/cm3. These higher values are likely a result of this site being located close to the shoreline of Lake Borgne. Conversely, the amount of organic content measured in the samples was higher inside of the project area than outside of the project area.

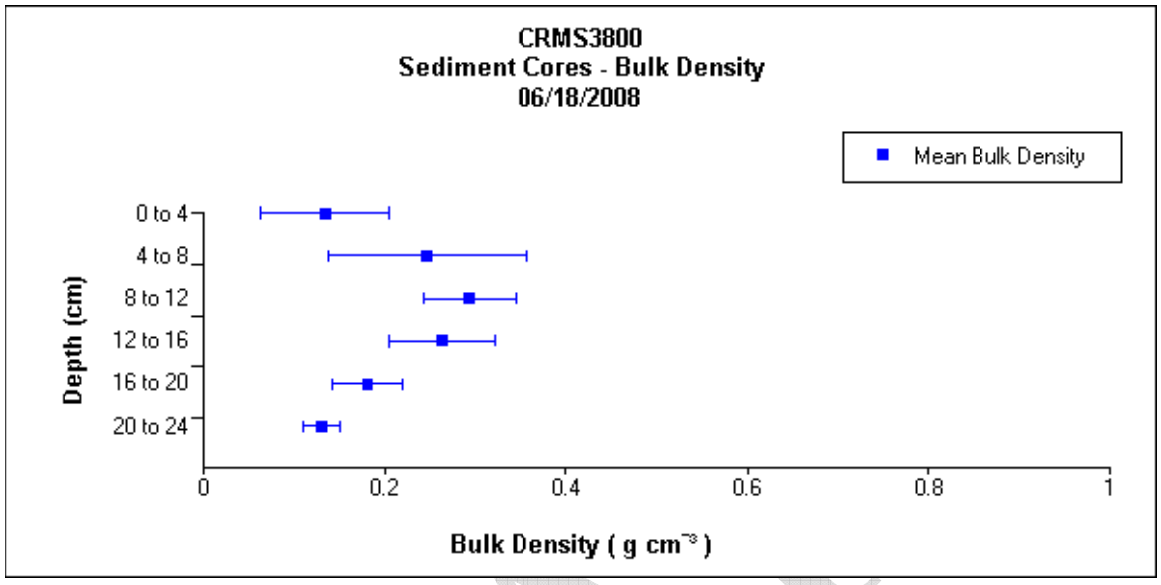


Figure 29. Soil bulk density at CRMS3800. Error bars represent standard deviations.

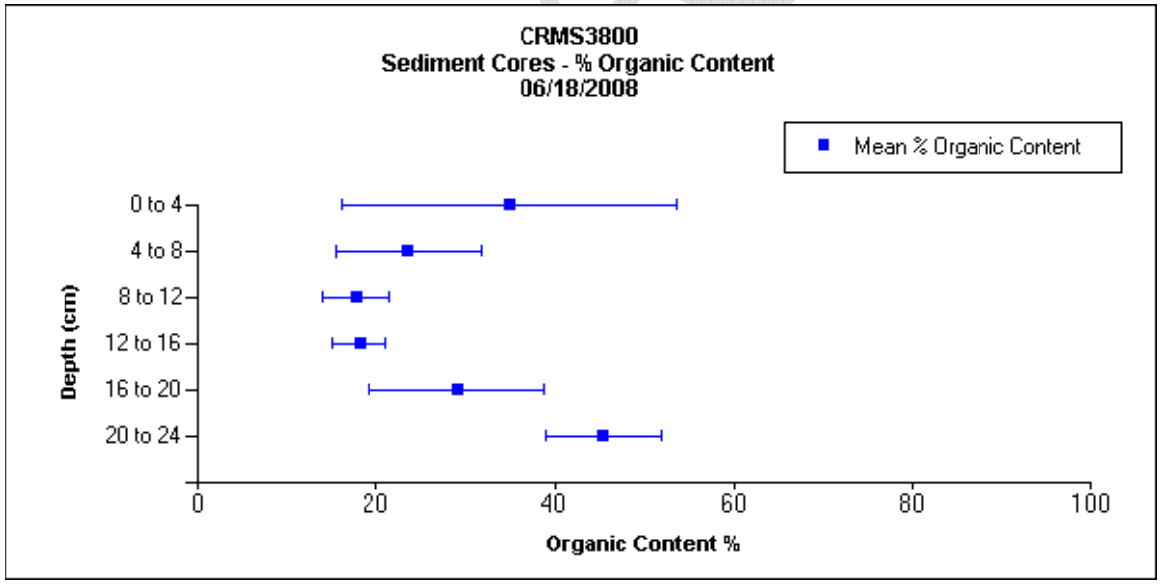


Figure 30. Soil percent organic content at CRMS3800. Error bars represent standard deviations.

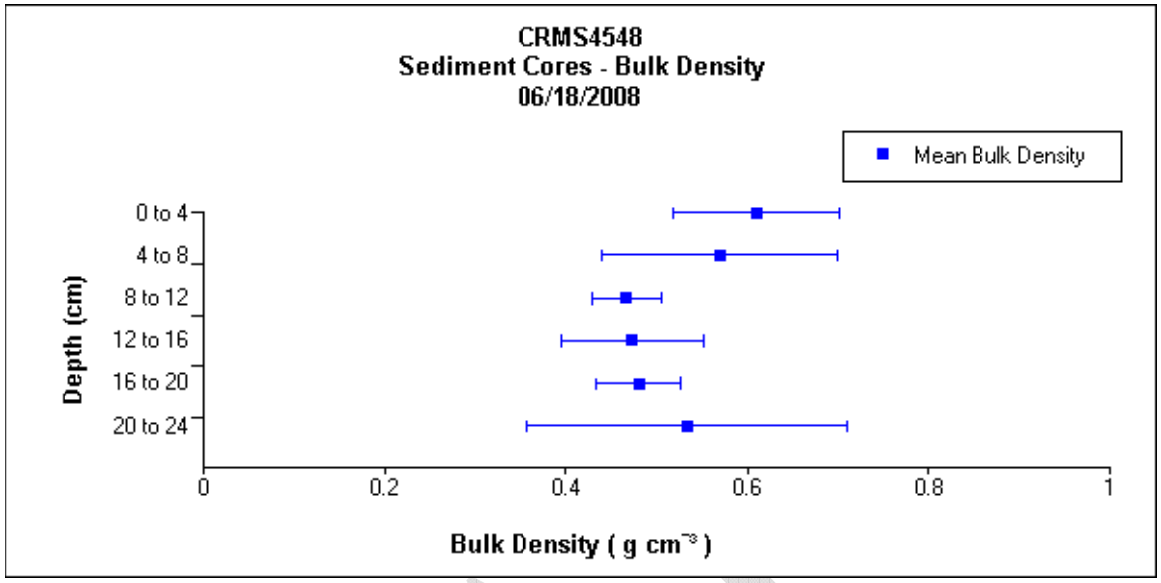


Figure 31. Soil bulk density at CRMS4548. Error bars represent standard deviations.

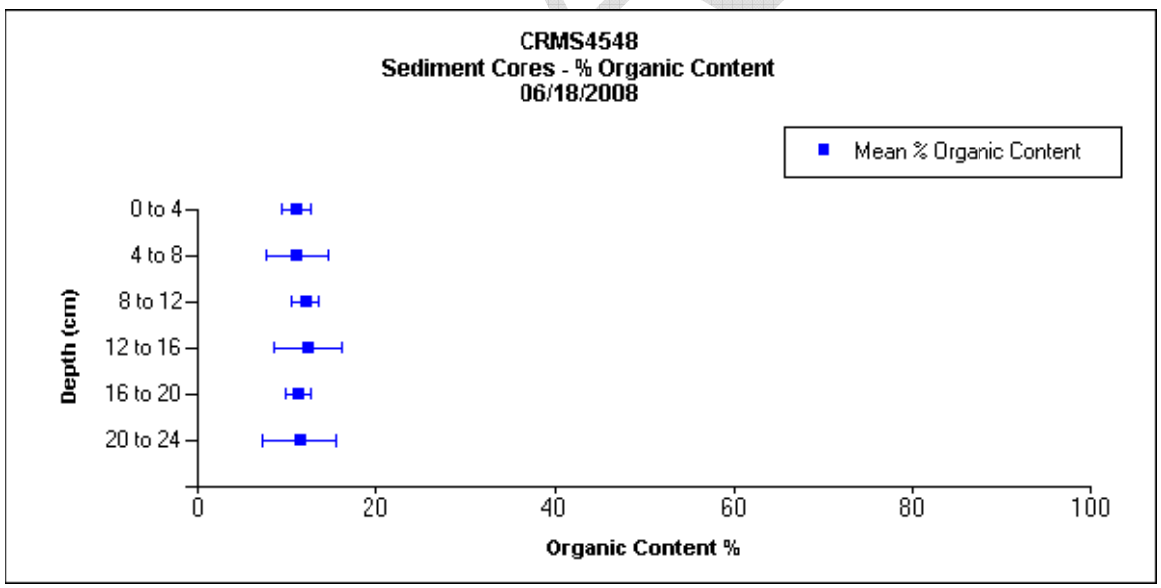


Figure 32. Soil percent organic content at CRMS4548. Error bars represent standard deviations.

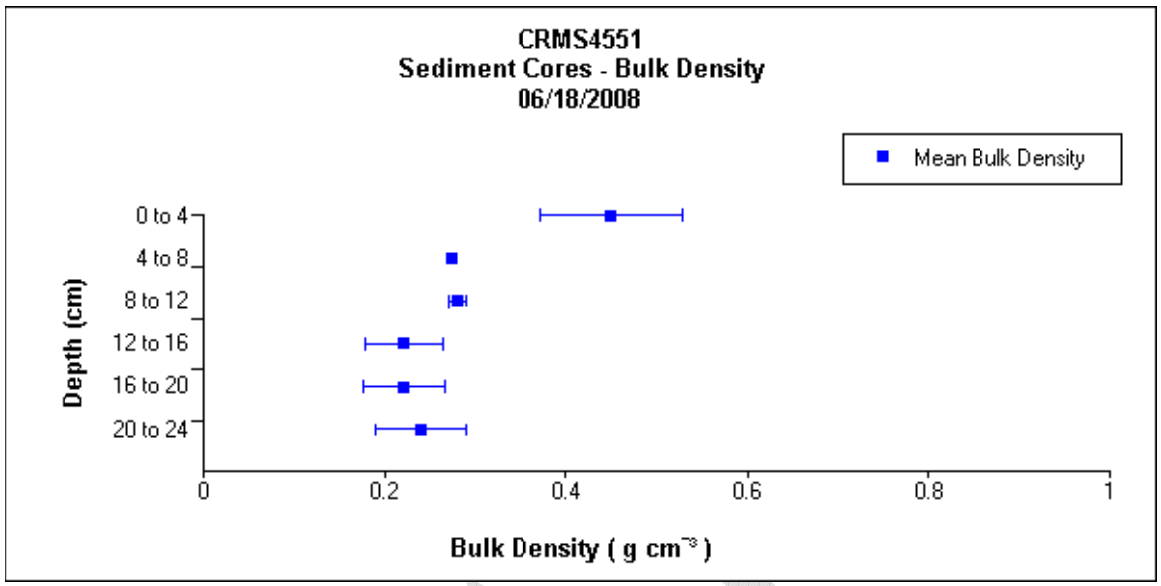


Figure 33. Soil bulk density at CRMS4551. Error bars represent standard deviations.

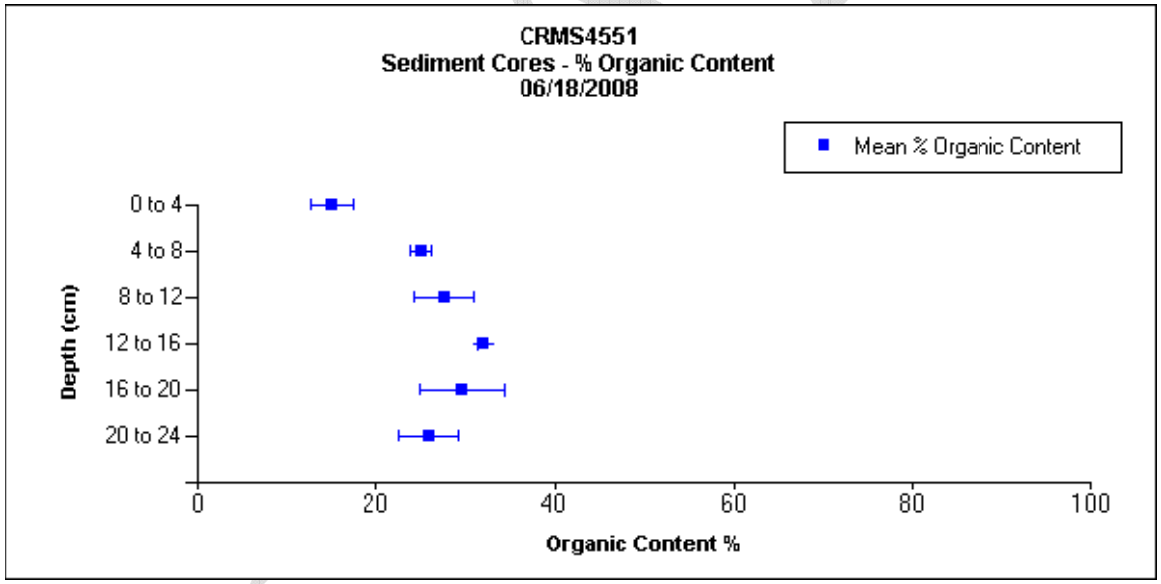


Figure 34. Soil percent organic content at CRMS4551. Error bars represent standard deviations.

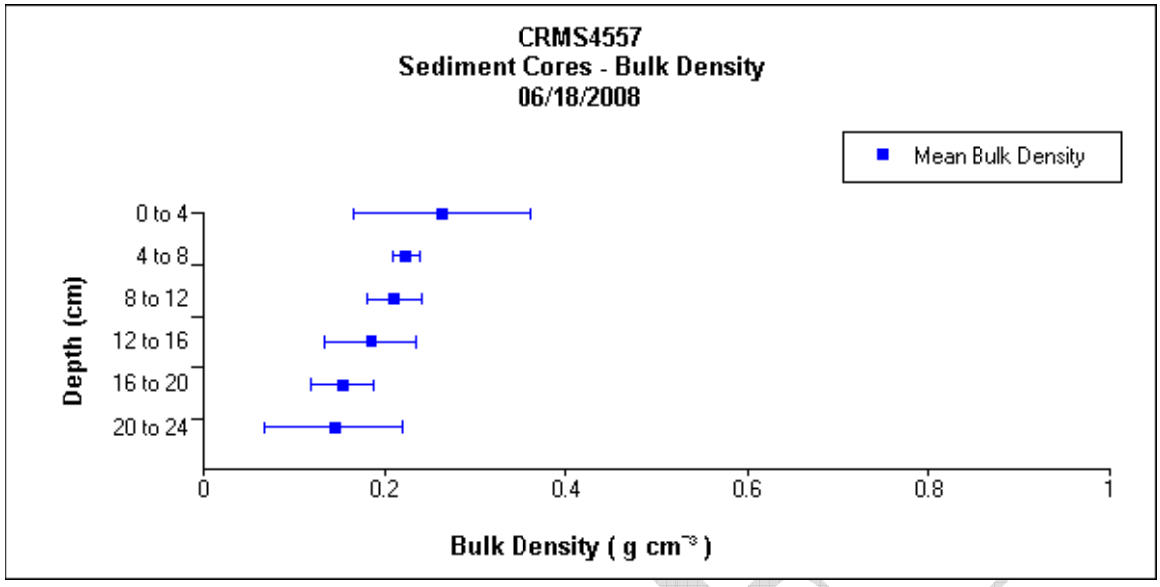


Figure 35. Soil bulk density at CRMS4557. Error bars represent standard deviations.

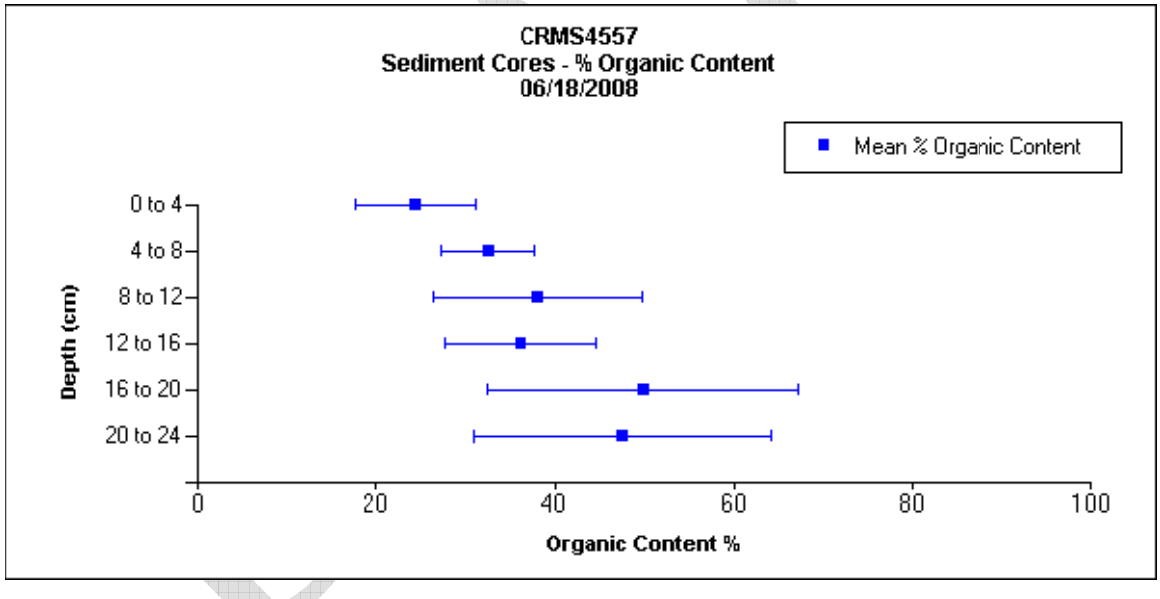


Figure 36. Soil percent organic content at CRMS4557. Error bars represent standard deviations.

Herbaceous Marsh Vegetation

Vegetative percent cover at all 4 CRMS sites are fairly high (~70% total cover) during the period of record monitored (Figures 37-40). CRMS3800 is classified as a brackish marsh and is dominated by *Spartina patens* while the other sites are classified as saline marshes and are dominated by *Spartina alterniflora*. The Floristic Quality Index (FQI) is consistent within each site outside of the PO24 project boundaries from 2007 to 2010. FQI at CRMS3800, however, is a bit lower than the other sites and shows a decrease in 2009. Typical disturbance species including *Amaranthus australis* colonized the site in 2009 and decreased in abundance in 2010 indicating that the vegetative shift and lower FQI may be a result of Hurricane Gustav which impacted the area in the Fall of 2008.

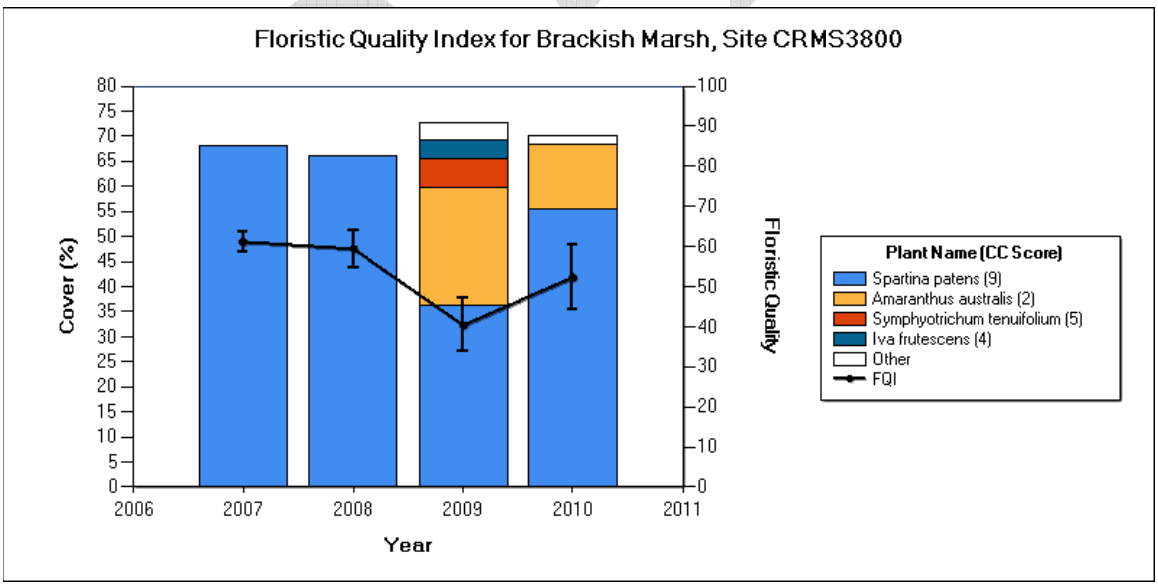


Figure 37. Vegetation percent cover and Floristic Quality Index for CRMS3800.

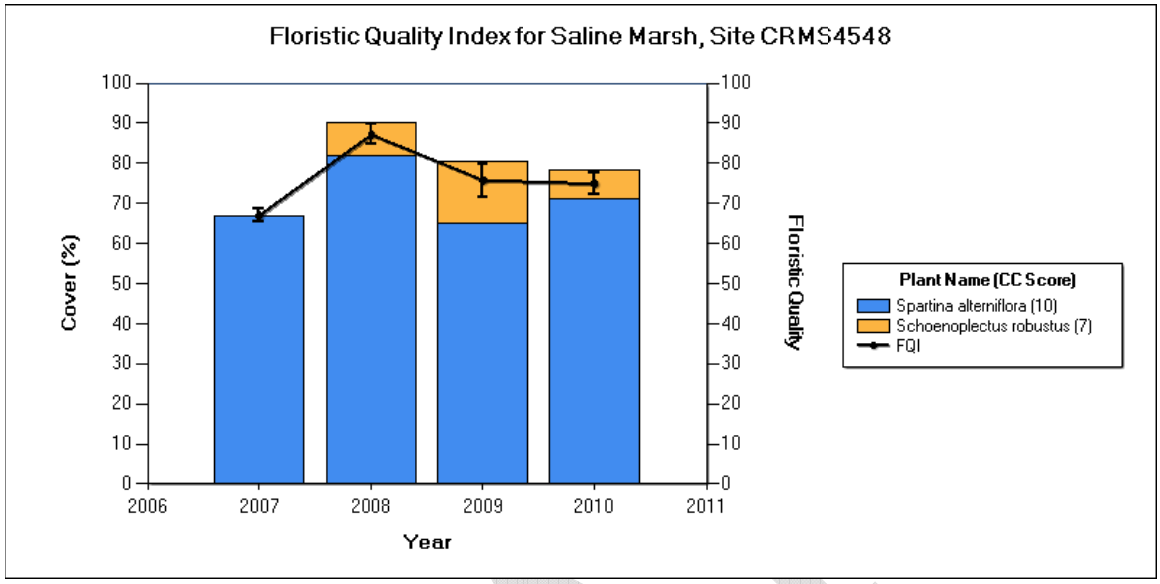


Figure 38. Vegetation percent cover and Floristic Quality Index for CRMS4548.

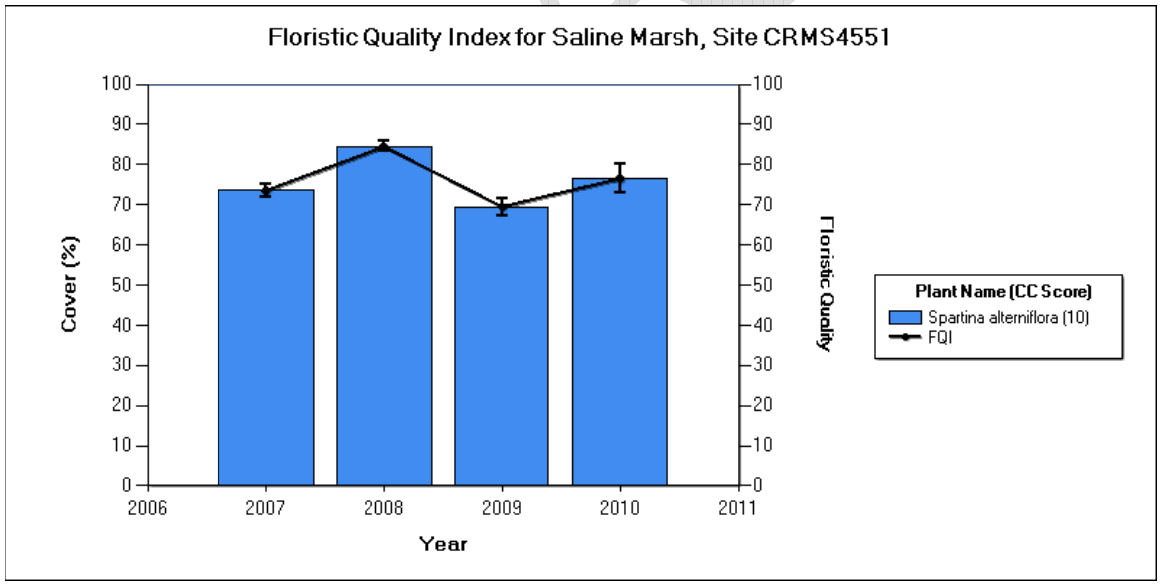


Figure 39. Vegetation percent cover and Floristic Quality Index for CRMS4551.

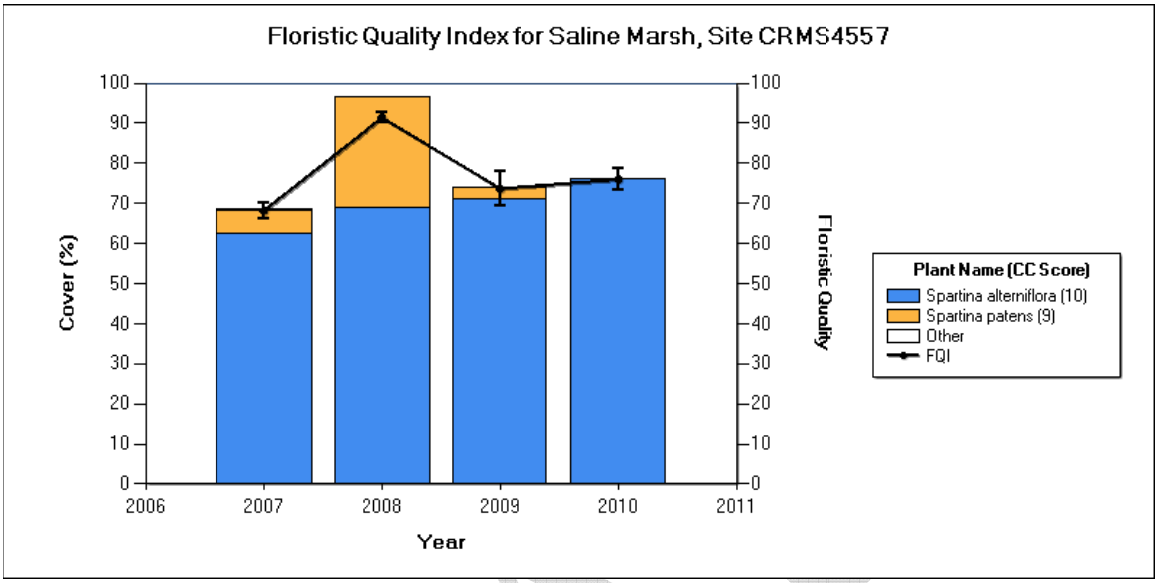


Figure 40. Vegetation percent cover and Floristic Quality Index for CRMS4557.

Marsh Surface Elevation Change and Vertical Accretion

Calculated rates of elevation change and vertical accretion are only available for two sites outside the project boundaries (Figures 41 and 42). While these sites estimate elevation and accretion gains on the order of 1.2-2.0 and <0.5 cm/yr, respectively, the regressions are only based on 2 years of data and caution should be used in making management decisions based on these numbers. Currently the CRMS data record for inside the project area is even shorter. As longer term data sets are acquired at CRMS sites, the confidence in projecting elevation changes over time will increase as will the ability to determine if the original monitoring goal of reducing flood events is being satisfied.

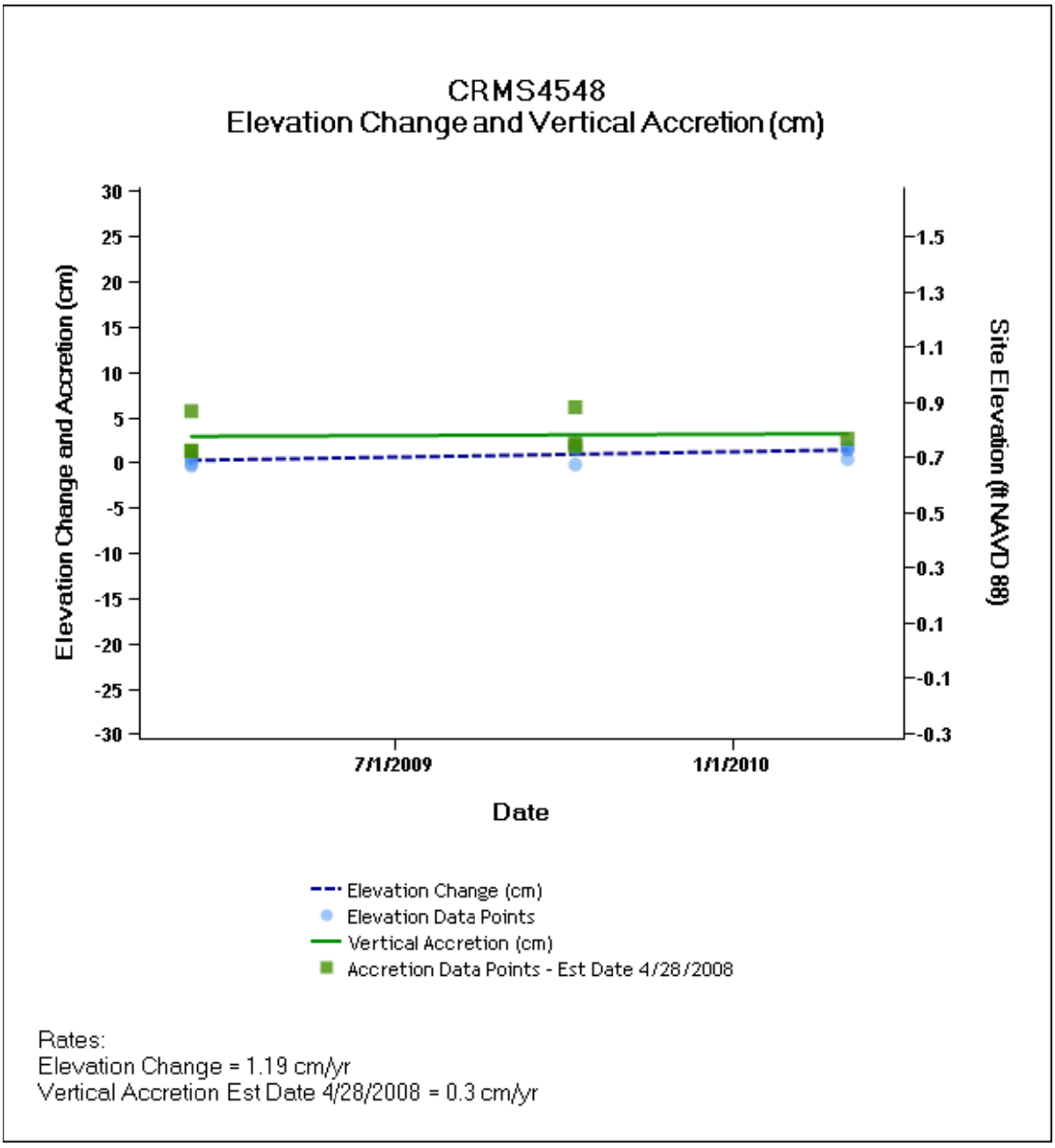


Figure 41. Marsh surface elevation change and vertical accretion for CRMS4548.

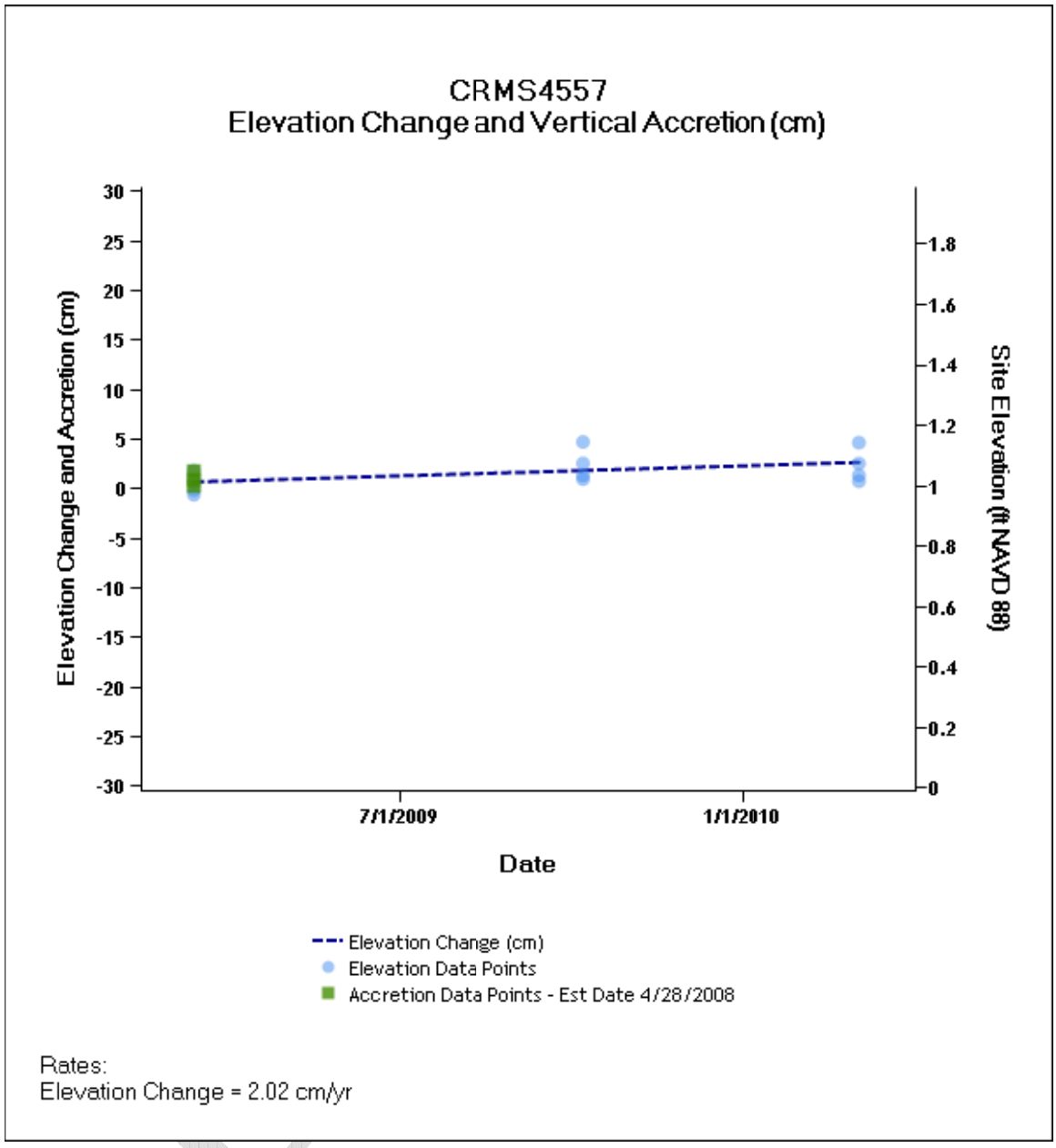


Figure 42. Marsh surface elevation change and vertical accretion for CRMS4557.

IV. Conclusions

a. Project Effectiveness

One of the monitoring goals of this project is to maintain the pre-construction acreage of vegetated wetlands over the life of the project. Until new aerial photography of the project area is acquired and analyzed in 2012 this goal cannot be evaluated. However, because land: water analyses are only scheduled every 10 years, ecological parameters measured more frequently at CRMS sites should be monitored and analyzed carefully since they provide important details in evaluating the health of the area on shorter intervals. In addition, as changes in land: water are quantified the CRMS data will provide a more detailed understanding of the processes driving the changes measured.

Reduction in salinity was not a specific goal of this project, however, surface water salinity did decrease significantly at all sites within the PO-24 project area. While this change was statistically significant, the biological significance is likely minor. Soil porewater salinity measured at CRMS3800, on the other hand, was often much higher (double in some instances) than surface water salinity suggesting that marsh vegetation in the area may be subjected to stressors not accurately accounted for by instruments positioned in open water. Since 2007, FQI values as well as vegetative composition and percent cover have remained fairly constant at all 4 CRMS sites indicating that, indeed, no changes have occurred as a result of salinity changes. With the project's close proximity to the MRGO near the closure location, multiple project sites and CRMS sites actively monitoring changes in salinity as well as CRMS sites measuring changes in vegetation, surface elevation, accretion, and soil characteristics in the project area will provide information necessary to better understand external influences vs. project influences.

Reduction in water levels and inundation frequency, which were specific goals of the project, occurred between the pre- and post- construction period at all stations within the project area. In addition, both PO-24 reference stations have shown an increase in water level during the post-construction period. There is a large amount of data missing for station PO24-04 and this may result in an underestimate of the mean weekly average for the post-construction period. Based on BACI paired analyses, water levels inside the project boundary decreased by 0.2-0.4 ft after project construction was complete. These results suggest that the project is successfully reducing marsh inundation intensity and duration. This decrease in water level coupled with reduced salinity will likely reduce stress to the marsh vegetation within the project area. As mentioned previously, continuing to monitor rates of wetland elevation change and accretion will be important

to effectively manage water level targets. In addition, changes in vegetation species composition and/or percent cover monitored during annual assessments at CRMS sites will provide an indication of potentially stressful conditions.

Finally, a recent study published in the *Journal of Experimental Marine Biology and Ecology* measured ingress and egress of fisheries through a water control structure and concluded the structure imposed no physical limitations (Kimball et al., 2010).

b. Recommended Improvements

Three PO-24 monitoring stations are schedule to be discontinued at the end of 2010 and only one CRMS site will exist within the project area. We recommend additional monitoring similar to CRMS in order to provide a better understanding of the marsh system within the project boundaries. CRMS3800 is located in an area that is not representative of the 3,805 acre project area and this single station within the project boundaries may not provide adequate data for proper analysis due the unusually low marsh elevation measured at this location. Because land: water analyses are only performed every 10 years, appropriate data should be collected more frequently to provide input on conditions which change on shorter time frames.

A second recommendation is to perform a more comprehensive marsh elevation survey of the area to help provide more accurate marsh inundation analyses.

c. Lessons Learned

Bayou La Loutre is a high traffic area. The continuous recorders located within the bayou were constantly being struck by marine vessels causing occasional data gaps. Station 2 was eventually moved to the bridge over the back dike canal at its intersection to Bayou La Loutre and has remained in-tact since. Station 4 has no such permanent structure to which it could be attached, and ultimately was removed.

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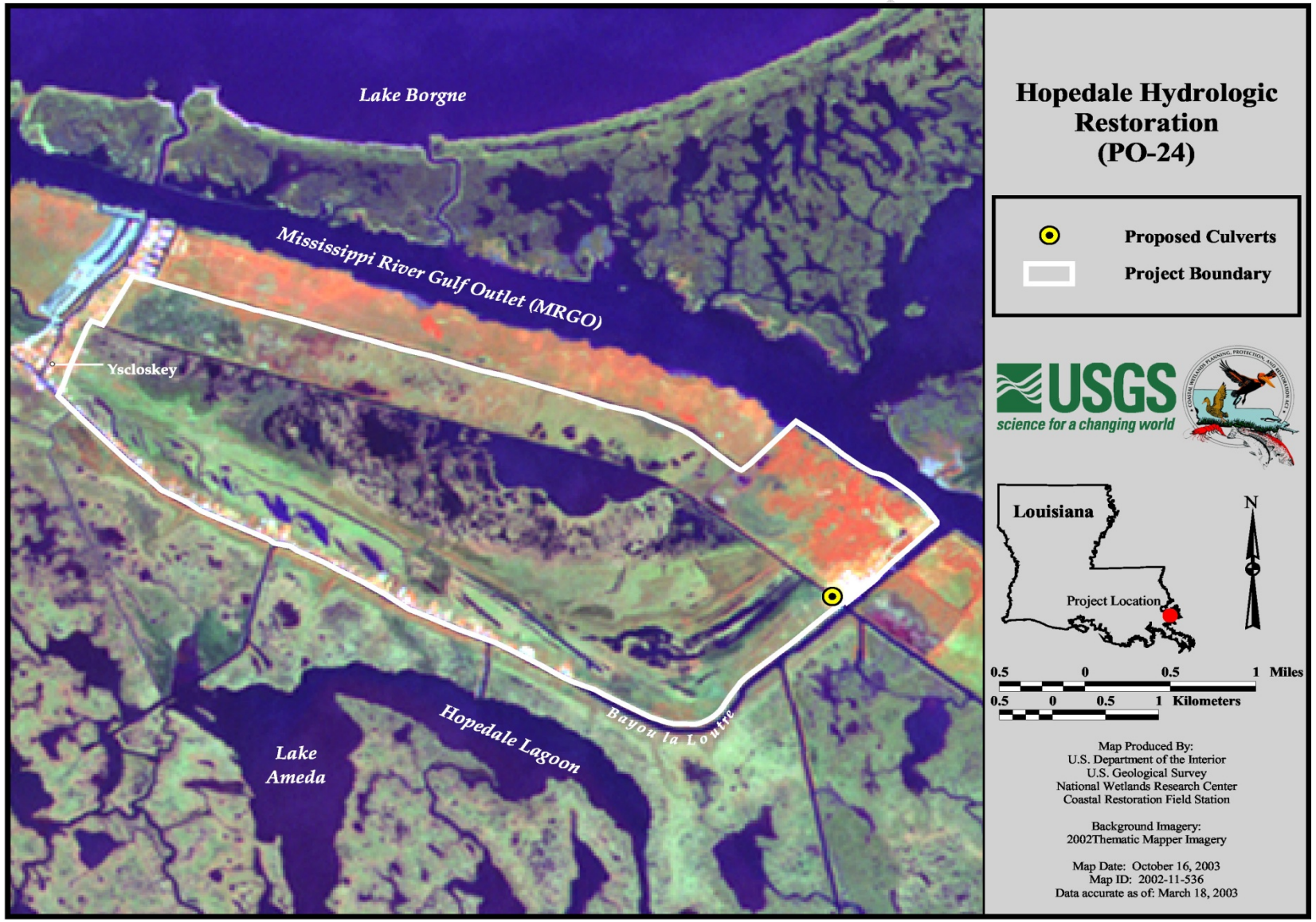
Appendix A

Project Features Map


Lake Borgne
Mississippi River Gulf Outlet (MRGO)
Ycloskey
Lake Ameda
Hopedale Lagoon
Bayou la Loutre
Hopedale Hydrologic Restoration (PO-24)
Proposed Culverts
Project Boundary
USGS
science for a changing world
Louisiana
Project Location
N
0.5 0 0.5 1 Miles
0.5 0 0.5 1 Kilometers
Map Produced By:
U.S. Department of the Interior
U.S. Geological Survey
National Wetlands Research Center
Coastal Restoration Field Station
Background Imagery:
2002Thematic Mapper Imagery
Map Date: October 16, 2003
Map ID: 2002-11-536
Data accurate as of: March 18, 2003

Appendix B

Photographs

(None Taken During This Inspection)

Appendix C

Three Year Budget Projection

Hopedale Hydrologic Restoration / PO-24 / PPL 8

Three-Year Operations & Maintenance Budgets 07/01/2010 - 06/30/2013

Project Manager	O & M Manager	Federal Sponsor	Prepared By
Barry Richard	*Barry Richard*	*NMFS*	*Barry Richard*

	2010/2011	2011/2012	2012/2013
Maintenance Inspection	$3,883.00	$3,984.00	$4,088.00
General Maintenance	$0.00	$0.00	$0.00
Structure Operation	$8,409.00	$8,628.00	$8,852.00
Administration	$4,000.00	$0.00	$0.00
Maintenance/Rehabilitation			

10/11 Description: Construction costs are for replacement of gate stem covers.

E&D	$79.20
Construction	$500.00
Construction Oversight	$30.00
Sub Total - Maint. And Rehab.	$ 609.20

11/12 Description:

E&D	$0.00	
Construction	$0.00	
Construction Oversight	$0.00	
Sub Total - Maint. And Rehab.	$ -	

12/13 Description:

E&D			$0.00
Construction			$0.00
Construction Oversight			$0.00
		Sub Total - Maint. And Rehab.	$ -

	2010/2011	2011/2012	2012/2013
Total O&M Budgets	$ 16,901.20	$ 12,612.00	$ 12,940.00

O &M Budget (3 yr Total)	**$ 42,453.20**
Unexpended O & M Budget	**$ 357,010.29**
Remaining O & M Budget (Projected)	**$ 314,557.09**

OPERATION AND MAINTENANCE BUDGET WORKSHEET 2010/2011

Hopedale Hydrologic Restoration / PO-24 / PPL 8

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
O&M Inspection and Report	EACH	1	$3,883.00	**$3,883.00**
General Structure Maintenance (Radio Equip.)	LUMP	1	$0.00	**$0.00**
Engineering and Design	LUMP	1	$79.20	**$79.20**
Operations	LUMP	1	$8,409.00	**$8,409.00**
Construction Oversight	LUMP	1	$30.00	**$30.00**
ADMINISTRATION				
LDNR / CRD Admin.	LUMP	1	$2,000.00	$2,000.00
FEDERAL SPONSER Admin.	LUMP	1	$2,000.00	$2,000.00
SURVEY Admin.	LUMP	1	$0.00	$0.00
OTHER				$0.00
			TOTAL ADMINISTRATION COSTS:	**$4,000.00**
MAINTENANCE / CONSTRUCTION				
SURVEY				
SURVEY DESCRIPTION:				
Secondary Monument	EACH	1	$0.00	$0.00
Staff Gauge / Recorders	EACH	1	$0.00	$0.00
Marsh Elevation / Topography	LUMP	1	$0.00	$0.00
TBM Installation	EACH	1	$0.00	$0.00
OTHER				$0.00
			TOTAL SURVEY COSTS:	**$0.00**
GEOTECHNICAL				
GEOTECH DESCRIPTION:				
Borings	EACH	1	$0.00	$0.00
OTHER				$0.00
			TOTAL GEOTECHNICAL COSTS:	**$0.00**
CONSTRUCTION				
CONSTRUCTION DESCRIPTION:				
Rip Rap	LIN FT	TON / FT	TONS	UNIT PRICE
	0	0.0	0	$0.00	$0.00
	0	0.0	0	$0.00	$0.00
	0	0.0	0	$0.00	$0.00
Filter Cloth / Geogrid Fabric		SQ YD	0	$0.00	$0.00
Navagation Aid		EACH	0	$0.00	$0.00
Signage		EACH	0	$0.00	$0.00
General Excavation / Fill		CU YD	0	$0.00	$0.00
Dredging		CU YD	0	$0.00	$0.00
Sheet Piles (Lin Ft or Sq Yds)			0	$0.00	$0.00
Timber Piles (each or lump sum)			0	$0.00	$0.00
Timber Members (each or lump sum)			0	$0.00	$0.00
Hardware		LUMP	1	$500.00	$500.00
Materials		LUMP	1	$0.00	$0.00
Mob / Demob		LUMP	1	$0.00	$0.00
Contingency		LUMP	1	$0.00	$0.00
General Structure Maintenance		LUMP	1	$0.00	$0.00
OTHER				$0.00	$0.00
OTHER				$0.00	$0.00
OTHER				$0.00	$0.00
			TOTAL CONSTRUCTION COSTS:	**$500.00**
			TOTAL OPERATIONS AND MAINTENANCE BUDGET:	**$16,901.20**

OPERATION AND MAINTENANCE BUDGET WORKSHEET 2011/2012

Hopedale Hydrologic Restoration / PO-24 / PPL 8

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
O&M Inspection and Report	EACH	1	$3,984.00	**$3,984.00**
General Structure Maintenance (Radio Equip.)	LUMP	1	$0.00	**$0.00**
Engineering and Design	LUMP	1	$0.00	**$0.00**
Operations	LUMP	1	$8,628.00	**$8,628.00**
Construction Oversight	LUMP	1	$0.00	**$0.00**
ADMINISTRATION				
LDNR / CRD Admin.	LUMP	0	$0.00	$0.00
FEDERAL SPONSER Admin.	LUMP	0	$0.00	$0.00
SURVEY Admin.	LUMP	0	$0.00	$0.00
OTHER				$0.00
			TOTAL ADMINISTRATION COSTS:	**$0.00**
MAINTENANCE / CONSTRUCTION				
SURVEY				
SURVEY DESCRIPTION:				
Secondary Monument	EACH	0	$0.00	$0.00
Staff Gauge / Recorders	EACH	0	$0.00	$0.00
Marsh Elevation / Topography	LUMP	0	$0.00	$0.00
TBM Installation	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL SURVEY COSTS:	**$0.00**
GEOTECHNICAL				
GEOTECH DESCRIPTION:				
Borings	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL GEOTECHNICAL COSTS:	**$0.00**
CONSTRUCTION				
CONSTRUCTION DESCRIPTION:				
Rip Rap	LIN FT	TON / FT	TONS	UNIT PRICE
	0	0.0	0	$0.00 $0.00
	0	0.0	0	$0.00 $0.00
	0	0.0	0	$0.00 $0.00
Filter Cloth / Geogrid Fabric		SQ YD	0	$0.00 $0.00
Navagation Aid		EACH	0	$0.00 $0.00
Signage		EACH	0	$0.00 $0.00
General Excavation / Fill		CU YD	0	$0.00 $0.00
Dredging		CU YD	0	$0.00 $0.00
Sheet Piles (Lin Ft or Sq Yds)			0	$0.00 $0.00
Timber Piles (each or lump sum)			0	$0.00 $0.00
Timber Members (each or lump sum)			0	$0.00 $0.00
Hardware		LUMP	1	$0.00 $0.00
Materials		LUMP	1	$0.00 $0.00
Mob / Demob		LUMP	1	$0.00 $0.00
Contingency		LUMP	1	$0.00 $0.00
General Structure Maintenance		LUMP	1	$0.00 $0.00
OTHER				$0.00 $0.00
OTHER				$0.00 $0.00
OTHER				$0.00 $0.00
			TOTAL CONSTRUCTION COSTS:	**$0.00**
			TOTAL OPERATIONS AND MAINTENANCE BUDGET:	**$12,612.00**

OPERATION AND MAINTENANCE BUDGET WORKSHEET 2012/2013

Hopedale Hydrologic Restoration / PO-24 / PPL 8

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
O&M Inspection and Report	EACH	1	$4,088.00	**$4,088.00**
General Structure Maintenance (Radio Equip.)	LUMP	1	$0.00	**$0.00**
Engineering and Design	LUMP	1	$0.00	**$0.00**
Operations	LUMP	1	$8,852.00	**$8,852.00**
Construction Oversight	LUMP	1	$0.00	**$0.00**
ADMINISTRATION				
LDNR / CRD Admin.	LUMP	0	$0.00	$0.00
FEDERAL SPONSER Admin.	LUMP	0	$0.00	$0.00
SURVEY Admin.	LUMP	0	$0.00	$0.00
OTHER				$0.00
			TOTAL ADMINISTRATION COSTS:	**$0.00**
MAINTENANCE / CONSTRUCTION				
SURVEY				
SURVEY DESCRIPTION:				
Secondary Monument	EACH	0	$0.00	$0.00
Staff Gauge / Recorders	EACH	0	$0.00	$0.00
Marsh Elevation / Topography	LUMP	0	$0.00	$0.00
TBM Installation	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL SURVEY COSTS:	**$0.00**
GEOTECHNICAL				
GEOTECH DESCRIPTION:				
Borings	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL GEOTECHNICAL COSTS:	**$0.00**
CONSTRUCTION				
CONSTRUCTION DESCRIPTION:				
Rip Rap	LIN FT	TON / FT	TONS	UNIT PRICE
	0	0.0	0	$0.00 $0.00
	0	0.0	0	$0.00 $0.00
	0	0.0	0	$0.00 $0.00
Filter Cloth / Geogrid Fabric		SQ YD	0	$0.00 $0.00
Navagation Aid		EACH	0	$0.00 $0.00
Signage		EACH	0	$0.00 $0.00
General Excavation / Fill		CU YD	0	$0.00 $0.00
Dredging		CU YD	0	$0.00 $0.00
Sheet Piles (Lin Ft or Sq Yds)			0	$0.00 $0.00
Timber Piles (each or lump sum)			0	$0.00 $0.00
Timber Members (each or lump sum)			0	$0.00 $0.00
Hardware		LUMP	1	$0.00 $0.00
Materials		LUMP	1	$0.00 $0.00
Mob / Demob		LUMP	1	$0.00 $0.00
Contingency		LUMP	1	$0.00 $0.00
General Structure Maintenance		LUMP	1	$0.00 $0.00
OTHER				$0.00 $0.00
OTHER				$0.00 $0.00
OTHER				$0.00 $0.00
			TOTAL CONSTRUCTION COSTS:	**$0.00**
			TOTAL OPERATIONS AND MAINTENANCE BUDGET:	**$12,940.00**

Appendix D

Field Inspection Form

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: **Hopedale Hydrologic Restoration Project (PO-24)**

Date of Inspection: 4/30/2010 Time: 10:30 am

Structure No. _____

Inspector(s): Richard

Structure Description: Gated Sheetpile Structure

Water Level Inside: N/A Outside: N/A

Type of Inspection: Annual

Weater Conditions: Clear Skies

Item	Condition	Pysical Damage	Corrosion	Photo #	Observations and Remarks
Swing Gates 84" D	Good	None	None		
Fish Gates 24" x 84"	Good	None	None		Gates were closed at time of inspection due to Oil Spill in the GOM.
Handrails Grating Hardware etc.	Good	None	None		Two gate stem covers missing.
Galv. Pile Caps	Good	None	None		
Signage /Supports	Good	None	None		
Riprap	Good	None	None		
Silt/Fill	Good	None	None		

Are there any signs of vandalism? No
Conditions of existing levees? Good
Noticable breaches? None